03.13 - 10/18/96 - 01708

FINAL

REMEDIAL INVESTIGATION REPORT OPERABLE UNIT NO. 13 (SITE 63)

TEXT AND FIGURES Volume I of II

MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

CONTRACT TASK ORDER 0340

OCTOBER 18, 1996

Prepared for:

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL FACILITIES
ENGINEERING COMMAND
Norfolk, Virginia

Under the:

LANTDIV CLEAN Program
Contract N62470-89-D-4814

Prepared by:

BAKER ENVIRONMENTAL, INC.
Coraopolis, Pennsylvania

TABLE OF CONTENTS

Page

EXECUTIVE SUMMARY ES-1

1.0 INTRODUCTION 1-1
1.1 Report Organization 1-1
1.2 Background and Setting of MCB, Camp Lejeune 1-2
1.2.1 Location and Setting 1-2
1.2.2 History 1-2
1.2.3 Operable Unit Description 1-2
1.2.4 Topography 1-2
1.2.5 Surface Water Hydrology 1-3
1.2.6 Geology 1-3
1.2.7 Hydrogeology 1-3
1.2.8 Ecology 1-5
1.2.9 Land Use Demographics 1-9
1.2.10 Meteorology 1-9
1.3 Background and Setting of Site 63 1-10
1.3.1 Site Location and Setting 1-10
1.3.2 Site History 1-10
1.4 Previous Investigations 1-11
1.4.1 Initial Assessment Study 1-11
1.4.2 Site Inspection 1-11
1.5 Remedial Investigation Objectives 1-13
1.6 References 1-13

2.0 SITE CHARACTERISTICS 2-1
2.1 Topography and Surface Features 2-1
2.2 Surface Water Hydrology 2-1
2.3 Soil 2-1
2.4 Geology 2-2
2.5 Hydrogeology 2-3
2.5.1 Groundwater Elevation Data 2-3
2.5.2 Groundwater Elevation Contour Maps 2-4
2.5.3 Hydraulic Properties 2-4
2.5.4 Groundwater Flow Velocities 2-5
2.5.5 General Groundwater Flow Patterns 2-5
2.6 Identification of Water Supply Wells 2-6
2.7 Site-Specific Ecology 2-6
2.7.1 Water Body Description 2-7
2.7.2 Sensitive Environments 2-7
2.8 References 2-9

TABLE OF CONTENTS
(Continued)

				Page
3.0	**STUDY AREA INVESTIGATIONS**			**3-1**
	3.1	Site Survey		3-1
	3.2	Soil Investigation		3-1
		3.2.1	Soil Sampling Procedures	3-2
		3.2.2	Sampling Locations	3-3
		3.2.3	Analytical Program	3-3
		3.2.4	Quality Assurance and Quality Control	3-3
		3.2.5	Air Monitoring and Field Screening	3-4
	3.3	Groundwater Investigation		3-5
		3.3.1	Monitoring Well Installation	3-5
		3.3.2	Monitoring Well Development	3-5
		3.3.3	Water Level Measurements	3-6
		3.3.4	Aquifer Testing	3-6
		3.3.5	Sampling Procedures	3-6
		3.3.6	Sampling Locations	3-7
		3.3.7	Analytical Program	3-7
		3.3.8	Quality Assurance and Quality Control	3-7
		3.3.9	Field Screening and Air Monitoring	3-7
	3.4	Surface Water and Sediment Investigations		3-7
		3.4.1	Sampling Procedures	3-8
		3.4.2	Sampling Locations	3-8
		3.4.3	Analytical Program	3-8
		3.4.4	Quality Assurance and Quality Control	3-8
	3.5	Ecological Investigation		3-9
	3.6	Decontamination Procedures		3-9
	3.7	Investigation Derived Waste (IDW) Management		3-9
	3.8	References		3-10
4.0	**NATURE AND EXTENT OF CONTAMINATION**			**4-1**
	4.1	Data Quality		4-1
		4.1.1	Data Management and Tracking	4-1
	4.2	Non-Site Related Analytical Results		4-1
		4.2.1	Laboratory Contaminants	4-2
		4.2.2	Naturally-Occurring Inorganic Analytes	4-2
	4.3	Analytical Results		4-4
		4.3.1	Soil Investigation	4-4
		4.3.2	Groundwater Investigation	4-7
		4.3.3	Surface Water Investigation	4-7
		4.3.4	Sediment Investigation	4-8
	4.4	Extent of Contamination		4-9
		4.4.1	Extent of Soil Contamination	4-9
		4.4.2	Extent of Groundwater Contamination	4-10
		4.4.3	Extent of Surface Water Contamination	4-11

TABLE OF CONTENTS
(Continued)

Page

4.4.4 Extent of Sediment Contamination 4-12
4.5 References 4-12

5.0 CONTAMINANT FATE AND TRANSPORT 5-1
5.1 Chemical and Physical Properties Impacting Fate and Transport 5-1
5.2 Contaminant Transport Pathways 5-2
5.2.1 Windblown Dust 5-3
5.2.2 Erosion of Soil Due to Surface Water Runoff 5-3
5.2.3 Leaching of Sediment Contaminants to Surface Water 5-3
5.2.4 Migration of Contaminants in Surface Water 5-4
5.2.5 Leaching of Soil Contaminants to Groundwater 5-4
5.2.6 Migration of Contaminants in Groundwater 5-4
5.3 Fate and Transport Summary 5-4
5.3.1 Volatile Organic Compounds (VOCs) 5-5
5.3.2 Semivolatile Organic Compounds (SVOCs) 5-5
5.3.3 Pesticides 5-5
5.3.4 Metals 5-5
5.4 References 5-7

6.0 BASELINE HUMAN HEALTH RISK ASSESSMENT 6-1
6.1 Introduction 6-1
6.2 Hazard Identification 6-2
6.2.1 Data Evaluation and Reduction 6-2
6.2.2 Identification of Data Suitable for Use in a Quantitative Risk Assessment 6-3
6.2.3 Criteria Used in Selection of COPCs 6-3
6.2.4 Contaminants of Potential Concern (COPCs) 6-8
6.3 Exposure Assessment 6-11
6.3.1 Potential Human Receptors and Adjacent Populations 6-11
6.3.2 Migration Exposure Pathways 6-12
6.3.3 Quantification of Exposure 6-15
6.3.4 Calculation of Chronic Daily Intakes 6-16
6.4 Toxicity Assessment 6-26
6.4.1 Carcinogenic Slope Factor 6-27
6.4.2 Reference Dose 6-27
6.4.3 Dermal Adjustment of Toxicity Factors 6-29
6.5 Risk Characterization 6-29
6.5.1 Carcinogenic Compounds 6-30
6.5.2 Noncarcinogenic Compounds 6-30
6.5.3 Human Health Risks 6-30
6.6 Evaluation of Lead 6-32

TABLE OF CONTENTS
(Continued)

Page

6.7 Sources of Uncertainty 6-32
6.7.1 Analytical Data 6-33
6.7.2 Exposure Assessment 6-33
6.7.3 Sampling Strategy 6-34
6.7.4 Toxicity Assessment 6-34
6.8 Conclusions of the BRA for Site 63 6-35
6.8.1 Current Scenario 6-36
6.8.2 Future Scenario 6-36
6.9 References 6-36

7.0 ECOLOGICAL RISK ASSESSMENT 7-1
7.1 Objectives, Scope, and Organization of the Ecological Risk Assessment ... 7-1
7.2 Problem Formulation 7-2
7.3 Contaminants of Potential Concern 7-2
7.3.1 Criteria for Selecting Contaminants of Potential Concern 7-2
7.3.2 Selection of Contaminants of Potential Concern 7-6
7.3.3 Physical/Chemical Characteristics of COPCs 7-8
7.4 Ecosystems Potentially at Risk 7-9
7.5 Ecological Endpoints 7-9
7.5.1 Aquatic Endpoints 7-9
7.5.2 Terrestrial Endpoints 7-10
7.6 Conceptional Model 7-10
7.6.1 Soil Exposure Pathway 7-10
7.6.2 Groundwater Exposure Pathway 7-11
7.6.3 Surface Water and Sediment Exposure Pathway 7-11
7.6.4 Air Exposure Pathway 7-11
7.7 Exposure Assessment 7-12
7.7.1 Surface Water and Sediment Sampling 7-12
7.8 Ecological Effects Characterization 7-13
7.8.1 Surface Water 7-13
7.8.2 Sediment 7-13
7.8.3 Surface Soil 7-14
7.9 Risk Characterization 7-16
7.9.1 Surface Water 7-17
7.9.2 Sediment 7-17
7.9.3 Terrestrial Chronic Daily Intake Model 7-18
7.9.4 Threatened and Endangered Species 7-18
7.9.5 Wetlands 7-18
7.9.6 Sensitive Environments 7-18
7.10 Ecological Significance 7-19
7.10.1 Aquatic Endpoints 7-19
7.10.2 Terrestrial Endpoints 7-19

7.11 Uncertainty Analysis 7-20
7.11.1 Sampling Methodology 7-20
7.11.2 Screening Levels 7-20
7.11.3 Terrestrial Models 7-21
7.12 Conclusions 7-22
7.12.1 Aquatic Ecosystem 7-22
7.12.2 Terrestrial Ecosystem 7-23
7.13 References 7-23

8.0 CONCLUSIONS AND RECOMMENDATION 8-1
8.1 Conclusions 8-1
8.1.1 Carcinogenic Risks 8-1
8.1.2 Noncarcinogenic Risks 8-1
8.1.3 Surficial Aquifer as Drinking Water Source 8-1
8.1.4 Ecological Risks 8-2
8.1.5 Positive Detections in Excess of Screening Criteria 8-2
8.1.6 Prevalence of Inorganic Analytes in Site Media 8-2
8.2 Recommendation 8-2
8.2.1 No Further Action 8-3

LIST OF APPENDICES

A	Test Boring Records
B	Test Boring and Well Construction Records
C	Bower and Rice Slug Test Solution Curves
D	Groundwater Flow Velocity Calculations
E	Chain-of-Custody Forms
F	Investigation Derived Waste Summary and Recommendations
G	Sampling Summaries
H	Frequency of Detection Summaries
I	Statistical Summaries
J	Field Duplicate Results
K	QA/QC Sampling Results
L	Grain Size, Total Organic Carbon, and Wet Chemistry Analytical Results
M	Base Background Analytical Results and Evaluation Reports
N	COPC Selection Summaries
O	Chronic Daily Intake Calculations
P	Permeability Constant Calculations
Q	White Oak River Basin Reference Stations
R	Terrestrial Reference Values and Chronic Daily Intake Calculations

LIST OF TABLES

1-1 Geologic and Hydrogeologic Units of North Carolina's Coastal Plain
1-2 Summary of Surficial Aquifer Hydraulic Properties Unrelated Site Investigations
1-3 Hydraulic Property Estimates of the Castle Hayne Aquifer and Confining Unit
1-4 Protected Species Within MCB, Camp Lejeune
1-5 Land Utilization Within Developed Areas of MCB, Camp Lejeune
1-6 Climatic Data Summary Marine Corps Air Station, New River
1-7 Summary of Well Construction Details
1-8 Positive Detections in Soil
1-9 Positive Detections in Groundwater
1-10 Positive Detections in Surface Water
1-11 Positive Detections in Sediment
1-12 Operable Unit No. 13 (Site 63) Remedial Investigation/Feasibility Study Objectives

2-1 Summary of Soil Physical Properties
2-2 Summary of Water Level Measurements

3-1 Soil Sample Summary (Test Borings)
3-2 Soil Sample Summary (Monitoring Well Test Borings)
3-3 Quality Assurance/Quality Control Sampling Program (Soil Investigation)
3-4 Summary of Well Construction Details
3-5 Summary of Water Level Measurements
3-6 Summary of Groundwater Field Parameters
3-7 Groundwater Sampling Summary
3-8 Quality Assurance/Quality Control Sampling Program (Groundwater Investigation)
3-9 Summary of Surface Water Field Parameters
3-10 Surface Water and Sediment Sampling Summary
3-11 Quality Assurance/Quality Control Sampling Program (Surface Water and Sediment)

4-1 Summary of Site Contamination
4-2 Surface Soil - Positive Detection Summary (Organic Compounds)
4-3 Surface Soil - Positive Detection Summary (Inorganic Analytes)
4-4 Subsurface Soil - Positive Detection Summary (Organic Compounds)
4-5 Subsurface Soil - Positive Detection Summary (Inorganic Analytes)
4-6 Groundwater - Positive Detection Summary (Organic Compounds)
4-7 Groundwater - Positive Detection Summary (Inorganic Analytes)
4-8 Surface Water - Positive Detection Summary (Organic Compounds)
4-9 Surface Water - Positive Detection Summary (Inorganic Analytes)
4-10 Sediment - Positive Detection Summary (Organic Compounds)
4-11 Sediment - Positive Detection Summary (Inorganic Analytes)

5-1 Organic Physical and Chemical Properties

6-1 Summary of Blank Contaminant Results
6-2 Summary of Data and COPC Selection - Organics in Surface Soil
6-3 Summary of Data and COPC Selection - Metals in Surface Soil
6-4 Summary of Data and COPC Selection - Organics in Subsurface Soil
6-5 Summary of Data and COPC Selection - Metals in Subsurface Soil

LIST OF TABLES
(Continued)

6-6 Summary of Data and COPC Selection - Organics and Metals in Groundwater
6-7 Summary of Data and COPC Selection - Organics and Metals in Surface Water
6-8 Summary of Data and COPC Selection - Organics and Metals in Sediment
6-9 Summary of Exposure Dose Input Parameters
6-10 Summary of Exposure Pathways
6-11 Summary of Health-Based Criteria
6-12 Summary of Dermally-Adjusted Health-Based Criteria
6-13 Summary of Risks - Current Military Receptor
6-14 Summary of Risks - Current Adolescent Trespasser
6-15 Summary of Risks - Future Child Resident
6-16 Summary of Risks - Current Adult Trespasser
6-17 Summary of Risks - Future Adult Resident
6-18 Summary of Risks - Future Construction Worker
6-19 Summary of Uncertainties
6-20 Total Site Risk

7-1 Frequency and Range of Contaminant Detections Compared to Surface Soil Background Values
7-2 Frequency and Range of Contaminant Detections Compared to Surface Water Screening Values
7-3 Frequency and Range of Contaminant Detections Compared to Sediment Screening Values
7-4 Contaminants of Potential Concern Per Media
7-5 Physical/Chemical Characteristics of the Contaminants of Potential Concern
7-6 Sediment Characterization Summary
7-7 Field Chemistry Data
7-8 Frequency and Range of Contaminants of Potential Concern Compared to Soil Flora and Fauna Screening Values
7-9 Exposure Factors for Terrestrial Chronic Daily Intake Model
7-10 Surface Water Quotient Index Per Station
7-11 Surface Water Quotient Index Per Contaminant of Potential Concern
7-12 Sediment Quotient Index Per Station
7-13 Sediment Quotient Index Per Contaminant of Potential Concern
7-14 Terrestrial Quotient Index

LIST OF FIGURES

1-1 Operable Unit 13 - Site 63
1-2 Operable Unit and Site Locations
1-3 Locations of Hydrogeologic Cross-Sections
1-4 Hydrogeologic Cross-Sections
1-5 Site Location Map Site 63, Verona Loop Dump
1-6 Site Map Site 63, Verona Loop Dump
1-7 Site Inspection Sampling Locations
1-8 Site Inspection Soil Analytical Results
1-9 Site Inspection Groundwater Analytical Results

2-1 Surface Contours
2-2 Cross Section Location Map
2-3A Hydrogeologic Cross-section A-A'
2-3B Hydrogeologic Cross-section B-B'
2-3C Hydrogeologic Cross-section C-C'
2-3D Hydrogeologic Cross-section D-D'
2-4A Static Water Elevation Trends (63-GW01, 63-GW02, 63-GW03, 63-TW01 and 63-TW02)
2-4B Static Water Elevation Trends (63-TW03, 63-TW04, 63-TW05, 63-TW07 and 63-TW08)
2-4C Static Water Elevation Trends (63-SG01 and 63-SG02)
2-5 Groundwater Elevation Contour Map (Feb. 1996)
2-6 Biohabitat Map
2-7 Location of Sensitive Environments

3-1 Soil Sampling Locations
3-2 Typical Temporary, Shallow Groundwater Monitoring Well Construction Diagram
3-3 Monitoring Well Locations
3-4 Surface Water and Sediment Sampling Locations

4-1 Organic Compounds in Surface Soil
4-2 Organic Compounds in Subsurface Soil
4-3 Selected TAL Metals in Surface Soil
4-4 Selected TAL Metals in Subsurface Soil
4-5 TAL Metals in Groundwater Above Screening Standards
4-6 TAL Metals in Surface Water Above Screening Standards
4-7 Organic Compounds in Sediment

6-1 Flowchart of Potential Exposure Pathways and Receptors

7-1 Conceptual Exposure Model for Ecological Receptors

LIST OF ACRONYMS AND ABBREVIATIONS

AET	Apparent Effects Threshold
AQUIRE	Aquatic Information Retrieval Database
ARAR	Applicable or Relevant and Appropriate Requirement
AST	Above Ground Storage Tank
ASTM	American Society for Testing and Materials
ATSDR	Agency for Toxic Substances and Disease Registry
AWQC	Ambient Water Quality Criteria
BaB	Baymeade
Baker	Baker Environmental, Incorporated
Bb	Beef Biotransfer Factor
BCF	Bioconcentration Factor
BEHP	Bis(2-ethylhexyl)phthalate
bgs	Below Ground Surface
BI	Biotic Index
Br	Plant Biotransfer Factor (fruit)
BRA	Baseline Human Health Risk Assessment
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene
Bv	Plant Biotransfer Factor (leaf)
°C	Degrees Celsius
Carc.	Carcinogenic Effects
CDI	Chronic Daily Intake
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CLEJ	Camp Lejeune
CLP	Contract Laboratory Program
COC	Contaminant of Concern
COPC	Contaminant of Potential Concern
CRAVE	Carcinogen Risk Assessment Verification Endeavor
CRDL	Contract Required Detection Limit
CRQL	Contract Required Quantitation Limit
CSF	Carcinogenic Slope Factor
DC	Direct Current
DEHNR	Department of Environmental Health and Natural Resources
DEM	Department of Environmental Management
DO	Dissolved Oxygen
DOD	Department of the Defense
DoN	Department of the Navy
DQO	Data Quality Objective
EDB	Ethyl Dibromide
EMD	Environmental Management Division (Camp Lejeune)
EPIC	Environmental Photographic Interpretation Center
ER-L	Effects Range - Low
ER-M	Effects Range - Median

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

ERA	Ecological Risk Assessment
ESE	Environmental Science and Engineering
°F	Degrees Fahrenheit
FFA	Federal Facilities Agreement
FID	Flame Ionization Detector
ft	Feet
FWS	Fish and Wildlife Service
gpm	Gallons per Minute
GW	Groundwater Well
H'	Species Diversity (Shannon-Wiener)
H	Species Diversity (Brillouins')
HA	Health Advisories
HEAST	Health Effects Assessment Summary Tables
HHAG	Human Health Assessment Group
HI	Hazard Index
HPIA	Hadnot Point Industrial Area
HQ	Hazard Quotient
i	Hydraulic Gradient
IAS	Initial Assessment Study
ICR	Estimated Incremental Lifetime Cancer Risk
ID	Internal Diameter
IDW	Investigation Derived Waste
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
K	Hydraulic Conductivity
K_{oc}	Organic Carbon Partition Coefficient
K_{ow}	Octanol Water Partition Coefficient
LANTDIV	Naval Facilities Engineering Command, Atlantic Division
LOAEL	Lowest-Observed-Adverse-Effect-Level
MAG	Marine Air Group
MBI	Macroinvertebrate Biotic Index
MCAS	Marine Corps Air Station
MCB	Marine Corps Base
MCL	Maximum Contaminant Level
MEK	Methyl Ethyl Ketone
MF	Modifying Factor
mg/L	Milligrams per Liter
mg/kg	Milligrams per Kilogram
MI	Mobility Index

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

MIBK	Methyl Isobutyl Ketone
msl	Mean Sea Level
NC DEHNR	North Carolina Department of Environment, Health, and Natural Resources
NCEA	National Center for Environmental Assessment
NCP	National Contingency Plan
NCWQS	North Carolina Water Quality Standards
ND	Nondetect
NE	Effective Porosity
NEESA	Naval Energy and Environmental Support Activity
NEHC	Navy Environmental Health Center
NFESC	Naval Facilities Engineering Service Center
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No-Observed-Adverse-Effect-Level
NOEL	No-Observed-Effect Level
Noncarc.	Noncarcinogenic Effects
NPL	National Priorities List
NTU	Nephelometric Turbidity Unit
NWI	National Wetlands Inventory
O&G	Oil and Grease
ORNL	Oak Ridge National Laboratory
OSWER	Office of Solid Waste and Emergency Response
OU	Operable Unit
PAH	Polynuclear Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PID	Photoionization Detector
ppb	Parts per Billion
ppm	Parts per Million
PVC	Polyvinyl Chloride
QA/QC	Quality Assurance/Quality Control
QI	Quotient Index
R	Retardation Factor
RA	Risk Assessment
RBC	Region III Risk-Based Concentration
RCRA	Resource Conservation and Recovery Act
RfD	Reference Dose
RI/FS	Remedial Investigation/Feasibility Study
RI	Remedial Investigation
RME	Reasonable Maximum Exposure
ROD	Record of Decision

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

S	Solubility
SA	Site Assessment
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SCS	Soil Conservation Service
SD	Sediment
SI	Site Investigation
Sj	Jaccard Coefficient
SM-SP	Fine Sand and Loamy Fine Sand
SMCL	Secondary Maximum Contaminant Level
SOP	Standard Operating Procedure
SQC	Sediment Quality Criteria
Ss	Sφrenson Index
SSL	Sediment Screening Level
SSV	Sediment Screening Value
SSSV	Surface Soil Screening Value
STP	Sewage Treatment Plant
SU	Standard Unit
SVOC	Semivolatile Organic Compound
SW	Surface Water
SWSV	Surface Water Screening Value
TAL	Target Analyte List
TBC	To Be Considered
TCE	Trichloroethylene
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
TDS	Total Dissolved Solids
TIC	Tentatively Identified Compound
TOC	Total Organic Carbon
TOC	Top-of-Casing
TPH	Total Petroleum Hydrocarbon
TRV	Terrestrial Reference Value
TSS	Total Suspended Solids
µg/dl	Micrograms per Deciliter
µg/L	Micrograms per Liter
µg/g	Micrograms per Gram
µg/kg	Micrograms per Kilogram
µmhos/cm	Micromhos per Centimeter
UBK	Uptake/Biokinetics
UCL	Upper Confidence Limit
UF	Uncertainty Factor
USCS	Unified Soil Classification System
USEPA	United States Environmental Protection Agency

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

USGS	United States Geological Survey
UST	Underground Storage Tank
V	Velocity
VOC	Volatile Organic Compound
VP	Vapor Pressure
WAR	Water and Air Research, Incorporated
WOE	Weight-of-Evidence
WQS	Water Quality Standards
WQSV	Water Quality Screening Values

EXECUTIVE SUMMARY

INTRODUCTION

This Remedial Investigation (RI) report evaluates the nature and extent of potential threats to public health and the environment posed by the release or threatened release of hazardous substances, pollutants, or contaminants at Operable Unit No. 13 (Site 63), Marine Corps Base (MCB), Camp Lejeune, North Carolina. Furthermore, this report supplies information and findings that support the Feasibility Study, Proposed Remedial Action Plan, and Record of Decision documents. The field investigation at Site 63 included sampling of soil, groundwater, surface water, and sediment environmental media; the resultant analytical data were evaluated; and both human health and ecological risk assessments were performed. The paragraphs which follow describe the findings of this RI.

Operable Unit Description

Operable units are formed as an incremental step toward addressing individual site concerns. There are currently 42 Installation Restoration Program (IRP) sites at MCB, Camp Lejeune, which have been grouped into 18 operable units. Operable Unit No. 13 is comprised of one site (Site 63) and is located within the western portion of the facility, to the south of Marine Corps Air Station (MCAS), New River.

Site Description and History

The Verona Loop Dump (Site 63) is comprised of approximately five acres and is located nearly two miles south of the MCAS, New River operations area. Vehicle access to the site is via Verona Loop Road, east from U.S. Route 17. The study area is located along Verona Loop Road approximately 1.25 miles from U.S. Route 17. Site 63 is bordered to the south by Verona Loop Road, to the east by an unnamed tributary to Mill Run, and to the west by a gravel access road.

Site 63 is relatively flat, however, the eastern portion slopes toward an intermittent stream along the eastern boundary of the study area. This unnamed tributary that borders the study area to the east, discharges into Mill Run approximately 2,000 feet south of Site 63. Mill Run then discharges into the Southwest Creek which eventually flows into the New River. A drainage ditch along Verona Loop Road receives surface water runoff from the extreme southern portion of the site and the asphalt road surface.

Much of the site is heavily vegetated with dense understory and trees greater than three inches in diameter. A partially improved gravel road provides access to the main portion of the study area; other unimproved paths extend outward from this road. Several personnel entrenchments, used during training exercises, have been excavated throughout the study area. Earthen berms and small to medium size trees have been felled to construct protective works around many of the entrenchments.

Very little information is known regarding the history or occurrence of waste disposal practices at Site 63. The study area reportedly received wastes generated during training exercises. The type of materials generated during these exercises are described only as "bivouac" wastes. Additional information suggests that no hazardous wastes were disposed of at Site 63. The years during which disposal operations may have taken place are not known. Training exercises, maneuvers, and recreational hunting are frequently conducted in the area. Photographs ES-1 through ES-6 depict conditions at Site 63.

SITE CHARACTERISTICS

The following provides information concerning the topography, surface water hydrology, geology, and hydrogeology of Site 63. Detailed information pertaining to site characteristics is presented in Section 2.0 of this report.

Topography and Surface Features

A topographic high occurs at Site 63 along a northeast-southwest trending axis located immediately west of the site's gravel access road. A "saddle" feature is apparent along this axis in the central portion of the study area due to a slight elevation decrease. The slope along the eastern side of the axis represents the west bank of an unnamed tributary. The grade along the western side of the axis falls gently to the west.

Site 63 is mainly wooded, with undergrowth. A small area containing a few dead and fallen trees was observed in the vicinity of well 63-GW02 during a site visit in February, 1995. However, new vegetation was observed in this area at the time of investigation. Bivouac and construction wastes have been observed throughout the study area. These wastes included Meals-Ready-to-Eat (MRE) packaging, ammunition containers, concrete debris, wood, and steel. Small soil mounds and personnel entrenchments were also observed throughout Site 63.

Geology

The uppermost geologic formation underlying Site 63 is an undifferentiated formation. The Belgrade Formation lies below, with the River Bend Formation below that. Due to the scope of this investigation, the borings at Site 63 are relatively shallow; none of the borings extended through the undifferentiated formation. The observed undifferentiated formation at Site 63 can generally be divided into two units; the upper unit and lower unit. The upper unit consists of relatively coarse-grained sediments; fine sands with lesser amounts of silt and clay. Lenses of silt or clay are also present within the upper unit. Silty sediments have replaced portions of the sand in the northwest portion of the site. The lower unit consists of relatively fine-grained silt and clay that typically have a distinct gray color. Predominantly fine-sandy sediments replace the silt and clay in the southeast portion of the site. Even though the lower unit generally contains finer-grained sediments than the upper unit, it does not appear to be a confining or semi confining unit. Water was frequently encountered in soils collected from borings penetrating the lower unit.

Hydrogeology

There are several aquifers and intervening confining units underlying MCB, Camp Lejeune. According to the U.S. Geological Survey (USGS) report, the surficial aquifer occurs within the sediments of the undifferentiated formation. The Castle Hayne confining unit occurs in sediments of the Belgrade Formation. Below the confining unit, the upper portion of the Castle Hayne aquifer occurs in sediments of the River Bend Formation.

Photograph ES-1: This photograph was taken facing north from the access road at Site 63. The gravel road pictured here provides access to the central portion of the study area; unimproved paths extend from this road.

Photograph ES-2: This photograph was taken facing northwest from Verona Loop Road toward Site 63. The study area is located along Verona Loop Road approximately 1.25 miles east of U.S. Route 17. The gravel access road, pictured in photograph ES-1, turns north at this location.

Photograph ES-3: This photograph was taken facing south from the gravel access road toward Town Point Road. As pictured, much of the site is heavily vegetated with dense understory and trees greater than three inches in diameter.

Photograph ES-4: This photograph depicts the unnamed tributary that borders Site 63 to the east and a survey stake which denotes a sampling station.

01708N02Y

Photograph ES-5: Reinforced concrete rubble, construction material, and various other inert debris pictured here was identified at Site 63. The observed material was limited to a number of distinct piles or areas, rather than being strewn throughout the study area.

Photograph ES-6: This photograph depicts one of the many personnel entrenchments, presumably constructed during training exercises, that have been excavated throughout the study area. As pictured, an earthen berm and felled trees have been used to form protective works.

01708N03Y

This study was limited to the uppermost aquifer, the surficial aquifer. The thickness of the surficial aquifer at Site 63 was not determined, due to the relatively shallow depths of the borings. Cross sections from the USGS report indicate that the Castle Hayne confining unit is absent west of Site 63. The surficial and Castle Hayne aquifers have a combined thickness of approximately 200 feet. The surficial and Castle Hayne aquifers are hydraulically connected in the absence of a confining unit.

Groundwater flow under the site appears divergent, perhaps radial, with flow to the west and to the east. A groundwater table high corresponds with a topographic high. Groundwater east of the divide appears to be flowing east toward the unnamed tributary at a velocity of approximately 0.73 feet/day. Groundwater appears to discharge to the unnamed tributary. The direction of groundwater flow and the relative elevations of the groundwater and the creek support this conclusion. Groundwater west of the divide appears to be flowing toward Mill Run at a velocity of approximately 0.08 feet/day. This conclusion is based on the location of the Mill Run stream valley with respect to the observed groundwater flow direction.

The varying groundwater flow velocities can be attributed to the variant hydraulic conductivity. The hydraulic conductivity measured at one monitoring well was 0.9 feet/day versus 3.9 feet/day at another. Variations in hydraulic conductivity may be expected in a heterogeneous aquifer, like the surficial aquifer at Site 63.

Potable Water Supply Wells

Two documents were reviewed to determine if water supply wells exist within a one-mile radius of Site 63. These reports included the Wellhead Management Program Engineering Study and the Preliminary Draft Wellhead Monitoring Study. Site 63 is located in a fairly remote area, away from the development associated with the MCAS, New River. No base water supply wells were found to be within a one-mile radius of Site 63.

REMEDIAL INVESTIGATION ACTIVITIES

The field investigation program at Site 63 was initiated to detect and characterize potential impacts to human health and the environment resulting from past waste management activities. This section discusses the site-specific RI field investigation activities that were conducted to fulfill that objective. The RI field investigation of OU No. 13 commenced on November 2, 1995 and continued through November 16, 1995. The RI field program at Site 63 consisted of a site survey; a soil investigation, which involved direct-push sample collection; a groundwater investigation, which included temporary monitoring well installation, sampling, and aquifer testing; a surface water and sediment investigation; and a habitat evaluation. The following provides an overview of the various investigation activities carried out during the RI:

- Surface Soil Samples Collected 46
- Subsurface Soil Samples Collected 50
- Temporary Wells Installed and Sampled 8
- Existing Shallow Wells Sampled 3
- Surface Water Samples Collected 5
- Sediment Samples Collected 5

The various investigations were performed at Site 63 to assess the nature and extent of contamination that may have resulted from previous waste management practices or site activities; assess the human health, ecological, and environmental risks associated with exposure to surface and subsurface soils; and characterize the geologic and hydrogeologic setting of the study area. Environmental samples (excluding general chemistry and engineering properties) were analyzed by Contract Laboratory Program methods using Level IV Data Quality Objectives; the resultant data were submitted for third party data validation.

EXTENT OF CONTAMINATION

The following provides a brief summary of the extent of contamination at Site 63. This summary focuses on the primary site concerns and is not intended to address all analytical results. Detailed findings and an evaluation are presented in Section 4.0 of this report. A summary of site contamination, by media, is provided in Table ES-1.

Soils

Styrene was detected in only one of the subsurface soil samples obtained at Site 63. Styrene was detected at a concentration of 41 µg/kg in a subsurface sample from location 63-SB15. No other volatile organic compounds (VOCs) were detected among the 96 soil samples retained for laboratory analyses. Given the limited extent of styrene and the lack corroborating evidence of volatile contamination, the presence of styrene is most likely the result of a single event rather than long-term disposal operations. Additionally, the single styrene detection did not exceed the applicable soil screening value of 2,000 µg/kg.

The presence of semivolatile organic compounds (SVOCs) in soil is most likely related to former operational activities at Site 63. The low concentration and infrequent detection of SVOCs among soil samples is consistent with the historical use of Site 63; most likely the result of incidental maneuvers and training exercises. Semivolatile compounds were identified in both surface and subsurface soil samples obtained from the suspected disposal portion of the study area. Concentrations of SVOCs were limited to two surface and three subsurface sampling locations throughout the entire site. The positive SVOC results correspond directly to the visual identification of graded soil or construction debris observed during the field investigation. None of the positive SVOC detections exceeded applicable soil screening values for the protection of groundwater, nor do they suggest long-term disposal operations. The presence of SVOCs in soil does suggest that vehicles or mechanized equipment may have been used at the site.

Positive detections of pesticides were observed in both surface and subsurface soil samples at Site 63. Pesticide concentrations were low (i.e., less than 0.1 mg/kg) and primarily limited to within and adjacent to the suspected disposal portion of the study area. The majority of pesticide detections were observed in surface soil samples. The frequency and overall concentration of pesticides in soil, nonetheless, does not suggest pesticide disposal activities. Much of the study area appears to have been graded during previous site operations; the reworked surface soil may have contained residual pesticides. The presence of pesticide compounds among soil samples obtained at Site 63 is most likely the result of routine base-wide application and use of pesticides.

As provided in Table ES-1, a number of samples submitted for analyses had target analyte list (TAL) metal concentrations which exceeded applicable soil screening values or base-specific background levels. Arsenic, barium, and nickel were detected at concentrations which exceeded soil screening values protective of groundwater among one, five, and seven of the 96 soil samples submitted for

TABLE ES-1

SUMMARY OF SITE CONTAMINATION
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction (units)	Detected Contaminants or Analytes	Comparison Criteria		Min.	Max.	Location of Maximum Detection	Detection Frequency	Detections Above		Distribution of Positive Detections
			Screening Standard	Base Background					Screening Standard	Base Background	
Surface Soil	Volatile (μg/kg)	ND	Soil SL	NA				0/46			
	Semivolatile (μg/kg)	Nitrosodiphenylamine	200	NA	51 J	51 J	SB12	1/45	0/45	NA	adjacent to 63-GW01
		Di-n-butylphthalate	120,000	NA	78 J	78 J	63-TW06	1/45	0/45	NA	southeast
		BEHP	11,000	NA	41 J	4,400	SB12	7/45	0/45	NA	1 exceeds blank conc.
	Pesticide (μg/kg)	Dieldrin	1.0	NA	3 J	4.1 J	SB32	3/46	3/46	NA	central, scattered
		4-4'-DDE	500	NA	2.7 J	55 J	SB35	7/45	0/45	NA	central, scattered
		4-4'-DDD	700	NA	12	26 J	SB35	2/45	0/45	NA	central and eastern
		Endosulfan Sulfate	NA	NA	1.9 J	2.8 J	SB18	4/45	NA	NA	central and northern
		4-4'-DDT	1,000	NA	2 J	50 J	SB29	11/45	0/45	NA	central, scattered
		alpha-Chlordane	NA	NA	3.5	16	SB35	2/45	NA	NA	central and eastern
		gamma-Chlordane	NA	NA	2.7 J	9	SB35	2/45	NA	NA	central and eastern
	PCB (μg/kg)	Aroclor-1260	NA	NA	28 J	97	SB30	2/45	NA	NA	central
	Metal (1) (mg/kg)	Arsenic	15	1.3	0.32	3.7	SB21	36/46	0/46	5/46	scattered
		Barium	32	17.3	3.0	53.1	SB35	46/46	3/46	8/46	scattered
		Beryllium	180	0.2	0.1 J	0.27	SB32	5/46	0/46	1/46	central
		Cadmium	6	0.7	1.0	3.1	SB21	2/46	0/46	2/46	central and eastern
		Chromium	NA	6.6	1.1	11.1	SB21	44/46	NA	6/46	scattered
		Copper	NA	7.1	0.47	74.8	SB29	29/46	NA	10/46	scattered
		Iron	NA	3,702	590	22,400	SB21	46/46	NA	9/46	scattered
		Lead	NA	23.4	2.6	107	SB29	46/46	NA	5/46	scattered
		Manganese	NA	18.5	3.4 J	348 J	SB03	46/46	NA	13/46	scattered
		Mercury	3	0.09	0.06	0.21 J	SB23	4/46	0/46	1/46	central
		Nickel	21	3.5	0.62 J	9.8	SB21	33/46	0/46	2/46	central
		Silver	NA	0.9	0.72	0.97	SB29	2/46	NA	1/46	central
		Zinc	42,000	13.8	0.98	1,860	SB21	36/46	0/46	7/46	scattered

TABLE ES-1 (Continued)

SUMMARY OF SITE CONTAMINATION
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction (units)	Detected Contaminants or Analytes	Comparison Criteria		Min.	Max.	Location of Maximum Detection	Detection Frequency	Detections Above		Distribution of Positive Detections
			Screening Standard	Base Background					Screening Standard	Base Background	
Subsurface Soil	Volatile (μg/kg)	Styrene	2,000	NA	41	41	SB15	1/50	0/50	NA	northwest
	Semivolatile (μg/kg)	Nitrosodiphenylamine	200	NA	94 J	350 J	SB19	2/49	1/49	NA	northern
		BEHP	11,000	NA	41 J	4,700	SB19	12/49	0/49	NA	3 exceed blank conc.
	Pesticide (μg/kg)	Dieldrin	1.0	NA	2.1 J	5.0 J	SB32	2/50	2/50	NA	northern and western
		4,4'-DDE	500	NA	2.6 J	2.8 J	SB22	2/50	0/50	NA	central
		4,4'-DDD	700	NA	5.6	5.6	SB22	1/50	0/50	NA	central
		4,4'-DDT	1,000	NA	7.8	7.8	SB20	1/50	0/50	NA	northern
	PCB (μg/kg)	ND	Soil SL	NA				0/50			
	Metal (1) (mg/kg)	Aluminum	NA	7,413	312	16,000	SB07	50/50	NA	32/50	scattered
		Antimony	NA	6.5	2.5 J	16.2 J	SB23	7/42	NA	1/42	central
		Arsenic	15	2	0.4	16	SB14	47/50	1/50	28/50	scattered
		Barium	32	14.4	2.5	1,120	SB23	50/50	2/50	8/50	scattered
		Beryllium	180	0.2	0.08	0.29	63-TW08	18/50	0/50	6/50	scattered
		Chromium	NA	12.5	1.2	84.4	SB23	50/50	NA	27/50	scattered
		Copper	NA	2.4	0.55	160	SB23	38/50	NA	27/50	scattered
		Iron	NA	7,135	425 J	149,000	SB23	50/50	NA	20/50	scattered
		Lead	NA	8.3	2 J	1,650	SB23	50/50	NA	11/50	scattered
		Manganese	NA	8.0	1.5	586	SB23	50/50	NA	18/50	scattered
		Nickel	21	3.7	1.0	76.1	SB26	44/50	7/50	19/50	scattered
		Silver	NA	0.9	1.8	5.3	SB23	2/50	NA	2/50	central
		Zinc	42,000	6.7	1.3	1,130	SB23	38/50	0/50	16/50	scattered
Groundwater	Volatile (μg/L)	ND	NCWQS/ MCL	NA				0/11			
	Semivolatile (μg/L)	ND	NCWQS/ MCL	NA				0/11			
	Pesticide (μg/L)	ND	NCWQS/ MCL	NA				0/10			
	PCB (μg/L)	ND	NCWQS/ MCL	NA				0/10			
	Total Metal (μg/L)	Iron	300	NA	73.5	24,300	63-TW05	8/11	4/11	NA	central
		Manganese	50	NA	1.8	311	63-GW02	11/11	4/11	NA	central
		Zinc	2,100	NA	4.9	17,100	63-TW07	6/11	1/11	NA	eastern

TABLE ES-1 (Continued)

SUMMARY OF SITE CONTAMINATION
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction (units)	Detected Contaminants or Analytes	Comparison Criteria		Min.	Max.	Location of Maximum Detection	Detection Frequency	Detections Above		Distribution of Positive Detections
			Screening Standard	Base Background					Screening Standard	Base Background	
Surface Water	Volatile (µg/L)	ND	NCWQS	NA				0/5			
	Semivolatile (µg/L)	ND	NCWQS	NA				0/5			
	Pesticide (µg/L)	ND	NCWQS	NA				0/5			
	PCB (µg/L)	ND	NCWQS	NA				0/5			
	Metal (2) (µg/L)	Aluminum	87	1,350	602	688	63-SW05	5/5	5/5	0/5	maximum downstream
Sediment	Volatile (µg/kg)	ND	NOAA ER-L	NA				0/5			
	Semivolatile (µg/kg)	ND	NOAA ER-L	NA				0/5			
	Pesticide (µg/kg)	4,4'-DDE	2	NA	4.2 J	4.2 J	63-SD04	1/5	1/5	NA	adjacent to site
		4,4'-DDD	2	NA	2.6 J	11 J	63-SD04	2/5	2/5	NA	adjacent to site
		4,4'-DDT	1	NA	1.6 J	1.6 J	63-SD04	1/5	1/5	NA	adjacent to site
		alpha-Chlordane	0.5	NA	4.7 J	4.7 J	63-SD04	1/5	1/5	NA	adjacent to site
		gamma-Chlordane	0.5	NA	6.2 J	6.2 J	63-SD04	1/5	1/5	NA	adjacent to site
	PCB (µg/kg)	ND	NOAA ER-L	NA				0/5			
	Metal (2) (mg/kg)	ND above screening val	NOAA ER-L	Background					0/5	0/5	

Notes: - Concentrations are presented in µg/L for liquid and µg/kg for solids (parts per billion), metal concentrations for soils and sediments are presented in mg/kg (parts per million).

(1) Metals in both surface and subsurface soils were compared to twice the average base background positive concentrations for aluminum, barium, iron, manganese and priority pollutant metals only (priority pollutant metals include antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, zinc).

(2) Total metals in surface water and sediment were compared to the range of positive detections in upgradient samples at MCB, Camp Lejeune.

BEHP - bis(2-Ethylhexyl)phthalate

NA - Not applicable

ND - Not detected

MCL - Federal Maximum Contaminant Level. Maximum permissible level of a contaminant in water which is delivered to any user of a public water system. U.S. Environmental Protection Agency - Drinking Water Regulations and Health Advisories.

NCWQS - North Carolina Water Quality Standards. Separate Values Applicable to Groundwater (North Carolina Administrative Code, Title 15A, Subchapter 2L) and Surface Water (North Carolina Administrative Code, Title 15A, Subchapter 2B).

NOAA ER-L - USEPA Region IV Sediment Effects-Range Low Screening Values, established by the National Oceanic and Atmospheric Administration.

Soil SL - USEPA Region III Soil Screening Levels for Protection of Groundwater, established by the Office of Solid Waste Emergency Response: R.L. Smith (October 4, 1995).

analyses; however, the same three inorganic analytes were not detected above North Carolina Water Quality Standard (NCWQS) levels among any of the groundwater samples obtained at Site 63.

The distribution of detected inorganic analytes among both surface and subsurface samples followed no discernible pattern. In at least one case, however, findings from the analytical program were consistent with visual observations of buried metal debris and non-native surface material recorded during the field investigation. A total of 13 inorganics were detected above twice their average base-specific background levels; 9 of the 13 analytes were detected at maximum concentrations in a subsurface sample obtained from location 63-SB23. Boring 63-SB23 is located within the central portion of the suspected disposal area and identified as having both surface and subsurface debris. With the exception of boring 63-SB23, inorganic analytes were observed at varying concentrations scattered throughout the study area.

__Groundwater__

Volatile, semivolatile, pesticide, and polychlorinated biphenyl (PCB) organic compounds were not detected in any of the groundwater samples submitted for analyses from Site 63. As a result of those analyses, the extent of organic compounds in groundwater are not addressed.

Inorganic analytes were detected in each of the 11 groundwater samples submitted for analyses from Site 63. Iron, manganese, and zinc were the only TAL total metals detected at levels in excess of either federal maximum contaminant level (MCL) or North Carolina WQS. Positive detections that exceeded applicable screening standards for both iron and manganese were distributed throughout the suspected disposal portion of the study area. The sample obtained from temporary well 63-TW07 exhibited the only positive detection of zinc that exceeded the 2,100 µg/L screening standard, zinc was detected at a concentration of 17,100 µg/L. Subsurface soil samples collected from both the eastern and western portions of the study area had positive detections of zinc which exceeded background levels. Although the distribution of zinc among soil samples is not limited to the suspected disposal portion of the study area, temporary well 63-TW07 is located within one of the areas identified as having elevated concentrations of zinc in soil. The presence of zinc in soil does not completely account for its elevated concentration in groundwater, however. One would expect that if zinc disposal operations had taken place at Site 63 elevated concentrations of zinc would also be evident in the adjacent monitoring well 63-GW02 and at much higher concentrations among soil samples obtained from the suspected disposal area. Temporary monitoring well 63-TW07 is hydraulically downgradient from the suspected disposal portion of the study area and permanent well 63-GW02. The limited dispersion of zinc in sampling media suggests that its presence is not indicative of former or ongoing disposal activities. Furthermore, zinc has not been detected at significant concentrations in the adjacent stream; a downgradient groundwater receptor.

Groundwater within the coastal plain region of North Carolina is naturally rich in iron and manganese. Groundwater concentrations of both iron and manganese at MCB, Camp Lejeune often exceed the state standards of 300 and 50 µg/L. Elevated levels of iron and manganese, at concentrations above the NCWQS, were reported in samples collected from a number of base potable water supply wells which were installed at depths greater than 162 feet below ground surface. Certain total metal concentrations in groundwater are due more to geologic conditions (i.e., naturally occurring concentrations and unconsolidated soils) and sample acquisition methods than to mobile metal concentrations in the surficial aquifer.

Iron and manganese concentrations from a number of wells at Site 63 exceeded the NCWQS but fell within the range of concentrations for samples collected elsewhere at MCB, Camp Lejeune. Additionally, positive detections of both iron and manganese among groundwater samples retained from the upper-most portion of the surficial aquifer had no discernible pattern of distribution. The presence and concentrations of both iron and manganese in groundwater samples obtained at Site 63 appear to be indicative of natural site conditions rather than disposal activities.

Surface Water

No organic compounds were detected among any of the five surface water samples submitted for analyses from Site 63. As a result of those analyses, the extent of organic compounds in surface water are not addressed.

Aluminum was the only TAL total metal identified among each of the five surface water samples obtained from the unnamed tributary that exceeded state or federal screening values. Each sampling station had a positive detection of aluminum above the 87 μg/L chronic screening value. Positive aluminum detections among the five surface water samples obtained from the unnamed tributary ranged from 602 to 688 μg/L. The headwaters of the unnamed tributary are less than one hundred yards upgradient of Site 63, amongst pine and hardwood trees. The combination of acidic soil and acidification due to decaying leaves and pine needles most probably has contributed to the slightly acidic nature of surface water at Site 63. Field chemistry results suggest that the pH of the unnamed tributary is less than 4.0. Several hundred or even several thousand milligrams per liter of aluminum is not unusual for natural waters having a pH below 4.0. The slight acidity of surface water at Site 63, coupled with the natural occurrence of aluminum in site soil and sediment has effectively contributed to the observed levels of aluminum among each of the surface water samples.

Sediment

None of the TAL metal sampling results from Site 63 exceeded chronic sediment screening values; therefore, the extent of inorganic analytes in sediment are not addressed. A summary of site contamination is presented in Table ES-1. Volatile, semivolatile, and PCB compounds were not detected among any of the five sediment samples submitted for analyses from Site 63. As a result of those analyses the extent of volatile, semivolatile, and PCB compounds in sediment are not addressed.

The pesticides 4,4'-DDE, 4,4'-DDD, 4,4'-DDT, alpha-chlordane, and gamma-chlordane were detected in one of the five sediment samples retained for analysis from Site 63. The only other pesticide detection was that of 4,4'-DDD in a sample obtained from a separate station. Each of the pesticides were detected at concentrations less than 15 μg/kg. The maximum pesticide concentration among the five sediment samples obtained for laboratory analysis was 11 J μg/kg of 4,4'-DDD. Each of the pesticide detections exceeded applicable chronic sediment screening values. The observed concentrations of the detected pesticides were typical of levels observed in sediments throughout MCB, Camp Lejeune. Positive detections of these compounds at Site 63 are most likely the result of former base-wide application and use of pesticides. The frequency and overall concentration of pesticides at Site 63 is not indicative of pesticide disposal activities.

HUMAN HEALTH RISK ASSESSMENT

The following highlights the media of interest from the human health standpoint at Site 63 by identifying areas with risk values greater than acceptable levels. Current and future potential receptors at the site included current military personnel, current trespassers (i.e., adolescents and adults), future residents (i.e., children and adults), and future construction workers. The total risk from the site for these receptors was estimated by logically summing the multiple pathways likely to affect the receptor during a given activity. Exposure to surface soil, surface water, and sediment was assessed for the current trespassers and military receptors. Surface soil, groundwater, surface water, and sediment exposure were evaluated for the future receptors.

Current Scenario

In the current case, the following receptors were assessed: military personnel and trespassers. Receptor exposure to surface soil, surface water, and sediment was assessed for current trespassers. Surface soil, subsurface soil, surface water, and sediment exposure were assessed for military personnel. The potential risks associated with the current receptors were within acceptable risk levels.

Future Scenario

In the future case, child and adult residents were assessed for potential exposure to groundwater, surface soil, surface water, and sediment. A construction worker was evaluated for subsurface soil exposure. There were no unacceptable risks associated with the construction worker. However, there were potential noncarcinogenic risks calculated for the child resident from groundwater (10.0) and subsurface soil (1.2) exposure. Similarly, there was a noncarcinogenic risk (4.5) calculated for the adult resident from groundwater exposure. These risk values exceeded the hazard index of 1 for noncarcinogenic effects. The maximum level of iron and zinc in groundwater were the primary contributors to these noncarcinogenic risks.

As stated previously, groundwater is not currently used potably at the site, and future residential development of the site is unlikely. Based on this information, the future groundwater exposure scenario evaluated in this risk assessment, although highly protective of human health, is unlikely to occur.

It should be noted that iron is an essential nutrient. The toxicity values associated with exposure to this metal are based on provisional studies, which have not been verified by the U.S. Environmental Protection Agency (USEPA). In fact, if iron were removed from the evaluation of risk from groundwater ingestion, the noncarcinogenic risk for the child would decrease from 10.0 to 4.8 and, for the adult, from 4.5 to 2.3. As a result, the potential human health risk from exposure to iron in groundwater is conservative.

The other analyte contributing to the unacceptable hazard index (HI) value in groundwater for the future residential child and adult is zinc. Zinc had a HQ of 3.6 for the future child resident and 1.6 for the future adult resident. While zinc was detected at a frequency of six out of eleven samples, only one detection exceeded the comparison criteria. This exceedence of 17,100 μg/L was detected at sample location 63-TW07. This concentration of zinc is one order of magnitude greater than those detected in Site 63 soils. In addition, zinc was not detected in surface water. Consequently, the potential human health risk from exposure to zinc in groundwater is a conservative estimate.

ECOLOGICAL RISK ASSESSMENT

The following subsections provide an overview of potential risks to the ecological environment identified at Site 63 during this assessment. Potential risks to the aquatic environment at Site 63 are demonstrated by the cumulative QI ratios greater than 1 calculated for both surface water and sediment. In addition, potential risks to the terrestrial environment are demonstrated by exceedances of soil toxicity values and risk exhibited in terrestrial chronic daily intake (CDI) models. However, the significance of the potential risks is considered to be low based on this ecological risk assessment.

Aquatic Ecosystem

Surface water concentrations of aluminum, barium, and lead may be adversely impacting the aquatic environment in the freshwater stream at Site 63. Cumulative quotient index (QI) ratios were calculated for the surface water at 1.31 for acute and 16.28 for chronic. These inorganic contaminants of potential concern (COPCs) were detected at relatively the same concentrations at each sampling location. However, due to the conservative barium criteria and lead in the blank sample, aluminum appears to be the only COPC potentially impacting the aquatic environment. It is noted that aluminum and barium were detected at higher concentrations during the 1991 Site Inspection. In addition, aluminum dissolves readily into surface water under acidic conditions and the pH concentrations detected at Site 63 surface water stations were below four. Therefore, the low pH levels are elevating the concentrations of aluminum detected in the surface water.

The potential risk to the aquatic community posed by the sediment is demonstrated by cumulative QI value of 11.33 for the effects range-low (ER-L). It is noted that risk is not demonstrated by the cumulative QI values calculated for the effects range-median (ER-M) (0.98) and sediment quality criteria (SQC) (0.66) values. The risk to the aquatic environment from the sediment is due to concentrations of chlordane, 4,4'-DDD, and 4,4'-DDE. However, these pesticides are not site-related contaminants, but rather a result of former base-wide pesticide control programs.

It should be noted that the intermittent, shallow nature of the stream may also introduce stress to the aquatic environment. The shallowness of the stream subjects the surface water to low dissolved oxygen concentrations and high temperatures both of which may adversely impact many aquatic organisms.

Terrestrial Ecosystem

Overall, minimal potential impacts to soil flora and fauna may occur as a result of concentrations of aluminum, chromium, copper, iron, lead, manganese, mercury, and zinc detected in the surface soil at Site 63. It should be noted that there is much uncertainty in the use of the flora and fauna surface soil screening values (SSSVs). In addition, the inorganics with the most exceedances of the SSSVs (aluminum, chromium, and iron) also exceed SSSVs for the background concentrations, indicating that regional conditions contribute to the potential risk to the terrestrial flora and fauna.

The terrestrial intake models only demonstrated a significant risk greater than one for the raccoon model. This risk was driven by concentrations of aluminum in the surface water via bioconcentration in fish tissue. It is noted that background surface water concentrations of aluminum also may generate a risk in the raccoon model. Therefore, regional conditions are contributing to the terrestrial risk to the vertebrate population at Site 63.

Conclusions

Based upon the information and findings supplied within this RI report, the following conclusions are presented.

Carcinogenic Risks

There are no unacceptable site-related carcinogenic risks associated with exposure to environmental media at Site 63. Multiple exposure pathways were evaluated for current and future potential human receptors; resultant estimates indicate that carcinogenic site risks are within the acceptable risk range as defined by USEPA.

Noncarcinogenic Risks

An assessment of potential noncarcinogenic risks posed by exposure to environmental media at Site 63 was also completed for possible current and future human receptors. This conservative evaluation of site risk suggests that future residents, given a number of exposure assumptions, could experience some adverse health effects. The evaluation was based upon the potential exposure of future child and future adult residents. Over 90 percent of noncarcinogenic risk generated by the future residential scenario is the result of presumed shallow groundwater ingestion. Ingestion of iron and zinc at the maximum concentrations detected among all groundwater samples obtained from Site 63 were used in the estimation of risk. Additionally, ingestion of iron at the maximum concentrations detected among soil samples constituted the remaining noncarcinogenic risk to future child residents. It is important to note that this risk assessment is highly protective of human health and that future residential development of the site is unlikely.

Surficial Aquifer as Drinking Water Source

The majority of site-related noncarcinogenic risk to future residents was generated by possible ingestion of metals in groundwater. Hydraulic conductivity results from Site 63 suggest that potable wells supplying groundwater for human consumption from the uppermost portion of the surficial aquifer would not be practical. Groundwater flow rates would not be sufficient to support a potable source of drinking water. In addition, suspended material resulting from loose surficial soils would further inhibit groundwater flow capacities through siltation. Given these circumstances, it is unlikely that the surficial aquifer could be used as a drinking water source. If a potable well were required in the future at Site 63 it would most likely supply groundwater from the deeper, Castle Hayne aquifer.

Ecological Risks

An ecological risk assessment of potential site-related impacts to both aquatic and terrestrial ecosystems was performed. Based upon this assessment, the significance of potential risks to ecological receptors at Site 63 are considered negligible. Environmental media were assessed to determine the theoretical risks posed to various on-site ecological communities. Results of the ecological risk assessment indicate that the aquatic environment may potentially be impacted by pesticides detected in the sediment and that risks posed to the terrestrial environment are a result of naturally occurring metals detected in the surface water and surface soil. Similar aquatic and terrestrial risks have been demonstrated by reference samples collected throughout MCB, Camp Lejeune from areas not known or suspected of having been impacted by facility operations

Positive Detections in Excess of Screening Criteria

A number of organic compounds and inorganic analytes were detected among environmental samples obtained from Site 63 at concentrations which exceeded screening criteria promulgated by either state or federal agencies. Dieldrin, n-nitrosodiphenylamine, arsenic, barium, and nickel were detected at concentrations exceeding USEPA Region III Soil Screening Levels for Protection of Groundwater among at least 7 of the 96 soil samples. Iron, manganese, and zinc were the only TAL metals detected in groundwater at concentrations in excess of state or federal screening standards. Iron and manganese detections exceeded applicable state standards among 4 of the 11 shallow groundwater samples, but fell within the range of concentrations for samples collected elsewhere at MCB, Camp Lejeune. Only one positive detection of zinc exceeded the state groundwater standard. Aluminum was the only TAL total metal identified among each of the five surface water samples obtained from the unnamed tributary that exceeded state or federal screening values. The pesticides 4,4'-DDE, 4,4'-DDD, 4,4'-DDT, alpha-chlordane, and gamma-chlordane were detected in one of the five sediment samples retained for analysis from Site 63. The only other pesticide detection was that of 4,4'-DDD in a sample obtained from an upstream station. Each of the pesticide detections exceeded applicable chronic sediment screening values.

Prevalence of Inorganic Analytes in Site Media

Inorganic analytes were detected in each soil, groundwater, surface water, and sediment sample obtained during the investigation at Site 63. Analytes such as aluminum, arsenic, iron, lead, manganese, and zinc were principal contributors to both human health and ecological site risks. These and other metals naturally occur, often abundantly, in site media. No discernible pattern of analyte distribution was evident among the various media sampled. Former site operations do not appear to have contributed to the presence or frequency of these analytes.

Recommendation

Based upon the conclusions, the following recommendation is presented.

No Further Action

A Proposed Remedial Action Plan that details a "No Further Action Alternative" should be prepared for Site 63. Project tasks associated with the screening and evaluation of remedial technologies and the subsequent preparation of a Feasibility Study report, given acceptance of the recommended alternative, will not be required. In addition, the three permanent monitoring wells that were installed at Site 63 during the 1991 Site Inspection should be abandoned (i.e., removed). Prior to project completion and following approval of the Record of Decision, abandonment of monitoring wells 63-GW01, 63-GW02, and 63-GW03 should proceed according to procedures stipulated by North Carolina's Department of Environmental Health and Natural Resources.

1.0 INTRODUCTION

Marine Corps Base (MCB), Camp Lejeune was placed on the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) National Priorities List (NPL) on October 4, 1989 (54 Federal Register 41015, October 4, 1989). Subsequent to this listing, the United States Environmental Protection Agency (USEPA) Region IV; the North Carolina Department of Environment, Health and Natural Resources (NC DEHNR); and the United States Department of the Navy (DoN) entered into a Federal Facilities Agreement (FFA) for MCB, Camp Lejeune. The primary purpose of the FFA is to ensure that environmental impacts associated with past and present activities at MCB, Camp Lejeune are thoroughly investigated and appropriate CERCLA response/Resource Conservation and Recovery Act (RCRA) corrective action alternatives are developed and implemented, as necessary, to protect public health, welfare, and the environment (FFA, 1989).

The Fiscal Year 1997 Site Management Plan for MCB, Camp Lejeune, the primary document referenced in the FFA, identifies 42 sites that require Remedial Investigation/Feasibility Study (RI/FS) activities. These 42 sites have been segregated into 18 operable units to simplify RI/FS activities. An RI was conducted at Operable Unit (OU) No. 13, Site 63, during November of 1995. This report describes the RI conducted at Site 63, the Verona Loop Dump. Figure 1-1 depicts the location of OU No. 13. [Note that all tables and figures are presented in the back of each section.]

The purpose of an RI is to evaluate the nature and extent of the threat to public health and the environment caused by the release or threatened release of hazardous substances, pollutants, or contaminants from a site. This RI investigation was conducted through the sampling of environmental media (soil, groundwater, surface water, and sediment) at Site 63, evaluating the resultant analytical data, and performing a human health risk assessment (RA) and ecological RA. This RI report contains the results of all field investigations, the human health RA, and the ecological RA. Furthermore, the RI report provides information to support the FS and Record of Decision (ROD) documents.

This RI Report has been prepared by Baker Environmental, Inc. (Baker) and submitted to the USEPA Region IV; the NC DEHNR; MCB, Camp Lejeune Environmental Management Department (EMD); the Navy Environmental Health Center (NEHC); the Agency for Toxic Substances and Disease Registry; and to the Naval Facilities Engineering Command, Atlantic Division (LANTDIV) for their review.

The following subsections describe the arrangement of OU No. 13 and the background and setting of both MCB, Camp Lejeune and Site 63. In addition, Section 1.1 provides an overview of the RI report's organization.

1.1 Report Organization

This RI Report is comprised of one text volume with appendices provided in an additional volume. The following section headings are included within this text volume and provide site-specific investigation findings:

- Study Area Investigation - Section 2.0
- Site Physical Characteristics - Section 3.0
- Nature and Extent of Contamination - Section 4.0

- Contaminant Fate and Transport - Section 5.0
- Baseline Human Health Risk Assessment - Section 6.0
- Ecological Risk Assessment - Section 7.0
- Conclusions - Section 8.0

1.2 Background and Setting of MCB, Camp Lejeune

This section summarizes existing background and setting information pertaining to MCB, Camp Lejeune. The text specifically addresses the location and setting of MCB, Camp Lejeune, its history, topography, geology, hydrogeology, climatology, ecology, land use, and demography.

1.2.1 Location and Setting

MCB, Camp Lejeune is located on the coastal plain of North Carolina in Onslow County. The facility encompasses approximately 234 square miles and is bisected by the New River. The New River flows in a southeasterly direction and forms a large estuary before entering the Atlantic Ocean. The southeastern border of MCB, Camp Lejeune is the Atlantic Ocean shoreline. The western and northeastern boundaries of the facility are U.S. Route 17 and State Route 24, respectively. The City of Jacksonville borders MCB, Camp Lejeune to the north (refer to Figure 1-1).

1.2.2 History

Construction of MCB, Camp Lejeune began in April 1941 at the Hadnot Point Industrial Area (HPIA), where major functions of the base are located today. The facility was designed to be the "World's Most Complete Amphibious Training Base." The MCB, Camp Lejeune complex consists of five geographical locations under the jurisdiction of the Base Command. These areas include Camp Geiger, Montford Point, Courthouse Bay, Mainside, and the Rifle Range Area (refer to Figure 1-1).

1.2.3 Operable Unit Description

Operable units are formed as an incremental step toward addressing individual site concerns. There are currently 42 Installation Restoration Program (IRP) sites at MCB, Camp Lejeune, which have been grouped into 18 operable units. Operable Unit No. 13 is located within the western portion of the facility, to the south of Marine Corps Air Station (MCAS), New River. Figure 1-2 depicts the locations of all 18 operable units at MCB, Camp Lejeune.

1.2.4 Topography

The flat topography of MCB, Camp Lejeune is typical of seaward portions of the North Carolina coastal plain. Elevations on the base vary from sea level to 72 feet above mean sea level (msl); however, most of MCB, Camp Lejeune is between 20 and 40 feet above msl. Drainage at MCB, Camp Lejeune is generally toward the New River, except in areas near the coast where flow is into the Intracoastal Waterway that lies between the mainland and barrier islands. In developed areas of the facility, natural drainage has been altered by asphalt cover (i.e., roadway and parking areas), storm sewers, and drainage ditches. Approximately 70 percent of MCB, Camp Lejeune is comprised of broad, flat interstream areas with poor drainage (WAR, 1983).

1.2.5 Surface Water Hydrology

The dominant surface water feature at MCB, Camp Lejeune is the New River. It receives drainage from a majority of the base. The New River is short, with a course of approximately 50 miles on the central Coastal Plain of North Carolina. Over most of its length, the New River is confined to a relatively narrow channel in Eocene and Oligocene limestones. South of Jacksonville, the river widens dramatically as it flows across less resistant sands, clays, and marls. At MCB, Camp Lejeune, the New River flows in a southerly direction into the Atlantic Ocean through the New River Inlet. Several small coastal creeks drain the area of MCB, Camp Lejeune not associated with the New River and its tributaries. These creeks flow into the Intracoastal Waterway, which is connected to the Atlantic Ocean by Bear Inlet, Brown's Inlet, and the New River Inlet. The New River, the Intracoastal Waterway, and the Atlantic Ocean converge at the New River Inlet.

Water quality criteria for surface waters in North Carolina have been published under Title 15 of the North Carolina Administrative Code. At MCB, Camp Lejeune, the New River falls into two classifications: SC (estuarine waters not suited for body-contact sports or commercial shellfishing); and SA (estuarine waters suited for commercial shellfishing). The SC classification applies to only three areas of the New River; the remainder of the New River at MCB, Camp Lejeune falls into the SA classification (ESE, 1990).

1.2.6 Geology

MCB, Camp Lejeune is located within the Atlantic Coastal Plain physiographic province. The sediments of this province consist primarily of sand, silt, and clay. Other sediments may be present, including shell beds and gravel. Sediments may be of marine or continental origin. These sediments are encountered in interfingering beds and lenses that gently dip and thicken to the southeast. Sediments of this type range in age from early Cretaceous to the later Quaternary time and overlie igneous and metamorphic rocks of pre-Cretaceous age. Table 1-1 presents a generalized stratigraphic column for the Atlantic Coastal Plain of North Carolina (Harned et al., 1989).

United States Geological Survey (USGS) studies at MCB, Camp Lejeune indicate that the base is underlain by sand, silt, clay, calcareous clay and partially cemented limestone. The combined thickness of these sediments beneath the base is approximately 1,500 feet.

1.2.7 Hydrogeology

The aquifers of primary interest are the surficial aquifer and the aquifer immediately below it, the Castle Hayne Aquifer. Other aquifers that occur beneath the facility include the Beaufort, Peedee, Black Creek, and upper and lower Cape Fear aquifers. The following summary is a compilation of information which pertains to aquifer characteristics within the MCB, Camp Lejeune area. A generalized hydrogeologic cross-section illustrating the relationship between the aquifers in this area is presented in Figures 1-3 and 1-4.

The surficial aquifer consists of interfingering beds of sand, clay, sandy clay, and silt that contain some peat and shells. The thickness of the surficial aquifer ranges from 0 to 73 feet and averages nearly 25 feet over the MCB, Camp Lejeune area. It is generally thickest in the interstream divide areas and presumed absent where it is eroded by the New River and its tributaries. The beds are thin and discontinuous, and have limited lateral continuity. The surficial aquifer is not used for water supply at MCB, Camp Lejeune.

The general lithology of the surficial aquifer and the absence of any thick, continuous clay beds are indications of relatively high vertical conductivity within the aquifer. The estimated lateral hydraulic conductivity of the surficial aquifer in the MCB, Camp Lejeune area is 50 feet per day, and is based on a general composition of fine sand mixed with some silt and clay (Harned et al.,1989). However, data from a number of aquifer tests conducted by Baker at sites near OU No. 13 indicate much lower hydraulic conductivity values. These values range from 7.2×10^{-4} feet per day to 6.4 feet per day. Table 1-2 presents a summary of hydraulic properties compiled during investigations at sites located within the developed portion of MCAS, New River.

Between the surficial and the Castle Hayne aquifers lies the Castle Hayne confining unit. This unit consists of clay, silt, and sandy clay beds. In general, the Castle Hayne confining unit may be characterized as a group of less permeable beds at the top of the Castle Hayne aquifer that have been partly eroded or incised in places. The Castle Hayne confining unit is discontinuous, and has a thickness ranging from 0 to 26 feet, averaging about 9 feet. Based upon previous investigatory data, there appears to be no discernable trend in the thickness of the confining unit, nor is there any information in the USGS literature regarding any trend to the depth of the confining unit.

Previously recorded data indicate that vertical hydraulic conductivity of the confining unit ranged from 3.0×10^{-2} to 4.1×10^{-1} feet per day (Cardinell et al., 1993). Data obtained from a pump test conducted by ESE indicated a vertical hydraulic conductivity for this unit ranging from 1.4×10^{-3} to 5.1×10^{-2} feet per day (ESE, 1988). Based on the moderate conductivity values and the thin, discontinuous nature of the confining unit, this unit may only be partly effective in retarding the downward vertical movement of groundwater from the surficial aquifer.

The Castle Hayne aquifer lies below the surficial aquifer and consists primarily of unconsolidated sand, shell fragments, and fossiliferous limestone. Clay, silt, silty and sandy clay, and indurated limestone also are present within the aquifer. The upper layer of the aquifer consists primarily of calcareous sand with some continuous and discontinuous thin clay and silt beds. The calcareous sand becomes more limey with depth. The lower part of the aquifer consists of consolidated or poorly consolidated limestone and sandy limestone interbedded with clay and sand.

The Castle Hayne aquifer is about 150 to 350 feet thick, increasing in thickness toward the ocean. The top of the aquifer lies approximately 20 to 73 feet below the ground surface. The top of the aquifer dips southward and is deepest near the Atlantic coast, east of the New River. The top of the aquifer also forms a basin in the vicinity of Paradise Point. Estimates of hydraulic conductivity indicate a wide variation in range, from 14 to 91 feet per day. Table 1-3 presents estimates of the Castle Hayne aquifer and confining unit hydraulic properties in the vicinity of MCB, Camp Lejeune.

Onslow County and MCB, Camp Lejeune are located in an area where the Castle Hayne aquifer generally contains freshwater; however, the proximity of saltwater in deeper layers just below the aquifer and in the New River estuary is of concern in managing water withdrawals. Over-pumping of the deeper parts of the aquifer could cause encroachment of saltwater. The aquifer generally contains water having less than 250 milligrams per liter (mg/L) chloride throughout the base, except for one USGS well in the southern portion of the base that is screened in the lower portion of the aquifer. Chloride was measured at 960 mg/L in a sample collected in 1989 from this well.

Rainfall over the MCB, Camp Lejeune area enters the ground in recharge areas, infiltrates the soil, and moves downward until it reaches the surficial aquifer. Recharge areas at Camp Lejeune are mainly comprised of interstream areas. In the surficial aquifer, groundwater flows in the direction of decreasing hydraulic head until it reaches discharge points or fronts. These discharge areas include the New River and its tributaries and the ocean. Though most of the rainfall entering the surficial aquifer discharges to local streams, a relatively small amount infiltrates to the Castle Hayne. The surficial aquifer supplies the primary recharge to the Castle Hayne aquifer. Like the surficial aquifer, the Castle Hayne naturally discharges to the New River and major tributaries; however, pumping of the Castle Hayne may locally influence flow directions.

The potentiometric surface of the surficial aquifer varies seasonally. The surficial aquifer receives more recharge in the winter than in the summer when much of the water evaporates or is transpired by plants before it can reach the water table. As a result, the potentiometric surface is generally highest in the winter months and lowest in the summer or early fall.

Water levels from wells placed in deeper aquifers, such as the Castle Hayne, were also used to establish potentiometric surfaces. The Castle Hayne is at least partially confined from the surficial aquifer and is not influenced by rainfall as strongly as the surficial aquifer; therefore, seasonal variations tend to be slower and smaller than in the surficial aquifer.

1.2.8 Ecology

The ecology at MCB Camp Lejeune is discussed in three sections that include ecological communities, sensitive environments, and threatened and endangered species.

1.2.8.1 <u>Ecological Communities</u>

MCB, Camp Lejeune is located on North Carolina's coastal plain. A number of natural ecological communities are present within this region. In addition, variations of natural communities have occurred in response to disturbance and intervention (e.g., forest clearing, urbanization). The natural communities found in the area are summarized as follows:

- Loblolly Pine Forest - One of the dominant forest types at MCB, Camp Lejeune. Pine forest often has a dense hardwood subcanopy and shrub understory as a result of clear-cutting and/or fire suppression. Dense shading results in a sparse ground layer of vegetation with little probability of rare species occurring (LeBlond et. al., 1994).

- Hardwood Forest - Found primarily in stream floodplains and on slopes and terraces adjacent to stream valleys and estuarine features. Stream floodplain communities include cypress-gum swamp and coastal plain small stream swamp. Very few rare species are found in hardwood forests, but the communities themselves can be quite rare (LeBlond et al., 1994).

- Loblolly Pine/Hardwoods Community - The predominant forest type at MCB, Camp Lejeune. Second growth forest that includes loblolly pine with a mix of hardwoods - oak, hickory, sweetgum, sour gum, red maple, and holly (oak is the predominant hardwood). These forests have a low probability for rare species because of the lack of herbaceous development and overall plant diversity (LeBlond et al., 1994).

- Longleaf Pine Forest and Longleaf Pine/Hardwood Forests - Contain critical, fire-maintained natural communities: Pine Savanna, Wet Pine Flatwoods, Mesic Pine Flatwoods, Pine/Scrub Oak Sandhill, and Xeric Sandhill Scrub. Some longleaf pine forests have developed in old fields and cut-over areas. The Federal endangered red-cockaded woodpecker (Picoides borealis) is essentially restricted to opened, burned longleaf pine forests. The pine savannas and wet pine flatwood communities are particularly important habitats for several rare species (LeBlond et al., 1994).

- Maritime Forest - Develop on the lee side of stable sands and dunes protected from the ocean. Live oak is an indicator species with pine, cedar, yaupon, holly, and laurel oak. Deciduous hardwoods may be present where forest is mature (USMC, 1987).

- Pond Pine Forest - These forests are primarily found in pocosins and are classified by Schafale and Weakley (1990) as the Pond Pine Woodland natural community. Red bay, sweet bay, and loblolly bay are important components of this community. These forests frequently produce areas of high plant diversity and support several rare species. The federal endangered loosestrife (Lysimachia asperulifolia) is found in this community (LeBlond et al., 1994).

- Freshwater Marsh - Occurs upstream from tidal marshes and downstream from non-tidal freshwater wetlands. Cattails, sedges, and rushes are present. On the coast of North Carolina, swamps are more common than marshes (USMC, 1987).

- Salt Marsh - These areas occur in saline tidal areas protected from tidal action by barrier beach features. The barrier islands fronting the Atlantic Ocean support Brackish Marsh, Upper Beach, Dune Grass, and Maritime Wet and Dry Grassland communities. Regularly flooded, tidally influenced areas dominated by salt-tolerant grasses. Saltwater cordgrass is a characteristic species. Tidal mud flats may be present during low tide. These dynamic communities are critical to such federal endangered species as the piping plover (Charadrius melodus) and the federal threatened American loggerhead turtle (Caretta caretta) and the green turtle (Chelonia mydas) LeBlond et al., 1994).

- Salt Shrub Thicket - High areas of salt marshes and beach areas behind dunes. These areas are subjected to salt spray and periodic saltwater flooding and are dominated by salt resistant shrubs (USMC, 1987).

- Dunes/Beaches - Zones between the ocean shore to the maritime forest. Subjected to sand, salt, wind, and water (USMC, 1987).

- Ponds and Lakes - Low depressional areas where water table is exposed at the surface or where ground is relatively impermeable. In ponds, rooted plants can grow across the bottom. Fish populations managed in these ponds include redear, bluegill, largemouth bass, and channel catfish (USMC, 1987).

- Open Water - marine and estuarine waters, as well as all underlying bottoms below the intertidal zone (USMC, 1987).

MCB, Camp Lejeune covers approximately 111,000 acres or 234 square miles. Marine and estuarine open water account for 26,000 acres and terrestrial and palustrine land account for 85,000 acres. Forests are the predominant terrestrial cover and pine forest is the dominant habitat type. A total of 21,000 acres of the pine forest are dominated by loblolly pine, 7,700 acres are comprised of longleaf pine forest, and 3,600 acres are dominated by pond pine forest. These pine forests include natural subcommunities that are maintained by fire.

In addition to the pine forest, mixed pine\hardwood forest is present on MCB, Camp Lejeune and accounts for 15,900 acres. An additional 12,100 acres are covered by hardwood forest. Of the wetlands present, estuarine marsh accounts for 700 acres; open freshwater accounts for 200 acres; and dune, beach, and brackish marsh accounts for 2200 acres. Industrial, infrastructure, and administrative areas make up 10,000 acres and artillery impact areas and buffer zones account for 11,000 acres (LeBlond, 1994). The base contains 80 miles of tidal streams, 21 miles of marine shoreline, and 12 freshwater ponds. The soil types range from sandy loams to fine sand and muck, with the dominant series being sandy loam (USMC, 1987).

The base drains primarily to the New River via its tributaries. These tributaries include Northeast Creek, Southwest Creek, Cogdels Creek, Wallace Creek, Frenchs Creek, Bear Head Creek, Brinson Creek, Edwards Creek, and Duck Creek. Site-specific information regarding surface water and drainage features is presented in Section 2.0.

Forested areas within the military reservation are actively managed for timber. Game species are also managed for hunting and ponds are maintained for fishing. Game species managed include wild turkey, white-tailed deer, black bear, grey and fox squirrels, bobwhite quail, eastern cottontail and marsh rabbits, raccoons, and wood ducks. About 150 acres are maintained as wildlife food plots.

1.2.8.2 Sensitive Environments

Two areas on MCB, Camp Lejeune have been registered as designated Natural Areas within the North Carolina Natural Heritage Program. These two areas, which encompass 141 acres, are the Longleaf Pine Natural Area and the Wallace Creek Swamp Natural Area. In addition, 12 other Natural Areas have been recommended for inclusion in the registry.

These Natural Areas contain some of the finest examples of natural communities in North Carolina and support many rare species. A few of these community types are globally rare. The Calcareous Coastal Fringe Forest on the 100-acre midden at Corn Landing is the only known extant example of this community type. Camp Lejeune contains some of the best examples of the following globally-rare, natural community types: Cypress Savanna, Depression Meadow, and Small Depression Pond. The Maritime Evergreen Forest hammocks between Cedar Point and Shell Point are connected by shell tombolos and appear to be a very rare geological formation.

The NC DEHNR's Division of Environmental Management (DEM) has developed guidance pertaining to activities that may impact wetlands (NC DEHNR, 1992). In addition, certain activities affecting wetlands are also regulated by the U.S. Army Corps of Engineers.

The U.S. Fish and Wildlife Service (FWS) has prepared National Wetlands Inventory (NWI) maps for the MCB, Camp Lejeune area. Through stereoscopic analysis of high altitude aerial photographs, wetlands were identified based upon vegetation, visible hydrology, and geography in accordance with Classification of Wetland and Deep-Water Habitats of the United States (Cowardin, et al., 1979). The NWI maps are intended for an initial identification of wetland areas and are not meant to replace an actual wetland delineation survey that may be required by federal, state and local regulatory agencies.

Site-specific wetland delineations were not conducted at Site 63; however, potential wetland areas were noted during the field habitat evaluation. Information regarding potential wetland areas was transferred to the site-specific biohabitat maps provided in Section 2.0. Information regarding sensitive natural areas was reviewed during map preparation and has been transferred to the maps, if applicable.

1.2.8.3 Threatened and Endangered Species

Certain species have been granted protection by the FWS under the Federal Endangered Species Act (16 U.S.C. 1531-1563), and by the North Carolina Wildlife Resources Commission, under the North Carolina Endangered Species Act (G.S. 113-331 to 113-337). The protected species fall into one of the following status classifications: federal or state endangered, threatened or candidate species; state special concern; state significantly rare; or state watch list. While only the federal or state threatened or endangered and state special concern species are protected from certain actions, the other classified species may have protection in the future.

Surveys have been conducted to identify threatened and endangered species at MCB, Camp Lejeune and several programs are underway to manage and protect them. Table 1-4 lists federally protected species present at the base and their protected classification. Of these species, the red-cockaded woodpecker, American alligator, and sea turtles are protected by specific regulatory programs.

The red-cockaded woodpecker requires a mature, living longleaf or loblolly pine environment. The birds live in family groups and young are raised cooperatively. At MCB, Camp Lejeune, 2,512 acres of habitat have been identified and marked for protection. Approximately 3,300 acres are in actively managed red-cockaded woodpecker colonies. Research on the bird at MCB, Camp Lejeune began in 1985 and information has been collected to determine home ranges, population size and composition, reproductive success, and habitat use. An annual roost survey is conducted and 36 colonies of birds have been located.

The American alligator is considered a state special concern specie. It is found in freshwater, estuarine, and saltwater wetlands in MCB, Camp Lejeune. Base wetlands are maintained and are protected for alligators; signs have been posted where alligators are known to live. Annual surveys of Wallace, Southwest, French, Duck, Mill, and Stone Creeks have been conducted since 1977 to identify alligators and their habitats on base.

Two protected sea turtles, the Atlantic loggerhead and Atlantic green turtle, nest on Onslow Beach at MCB, Camp Lejeune. The green turtle was found nesting in 1980; this sighting was the first time the species had been observed nesting north of Georgia. The turtle returned to nest in 1985. Turtle nests on the beach are surveyed and protected, turtles are tagged, and annual turtle status reports are issued.

Three bird species, piping plover, Bachmans sparrow, and peregrine falcon have also been identified during surveys at MCB, Camp Lejeune. The piping plover is a shore bird. Piping plovers prefer beaches with broad open sandy flats above the high tide line and feed along the edge of incoming waves. Like the piping plover, Bachmans sparrows have very specific habitat requirements. The sparrows live in open stretches of pines with grasses and scattered shrubs for ground cover. Bachmans sparrows were observed at numerous locations throughout southern portion MCB, Camp Lejeune.

In addition to the protected species that breed or forage at MCB, Camp Lejeune, several protected whales migrate through the coastal waters off the base during spring and fall. These include the Atlantic right whale, finback whale, sei whale, and sperm whale. Before artillery or bombing practice is conducted in the area, aerial surveys are made to assure that whales are not present in the impact areas.

A natural heritage resource study was conducted at MCB, Camp Lejeune (LeBlond, 1994) to identify threatened or endangered plants and areas of significant natural interest. During the resource study 55 rare plant species were documented at MCB, Camp Lejeune. These include one specie that is classified as federally endangered, one specie that is classified as federally threatened, nine that are candidates for federal listing as endangered or threatened, four that are listed as endangered or threatened in the State of North Carolina, and 27 species that are state rare or state special concern. These species are summarized on Table 1-4. In addition, species that are candidates for state listing or are on the North Carolina state watch list were noted.

1.2.9 Land Use Demographics

MCB, Camp Lejeune encompasses an area of approximately 234 square miles. The Installation border is approximately 70 miles, including 21 miles of ocean front and Intracoastal Waterway. Recently, MCB, Camp Lejeune acquired approximately 41,000 additional acres in the Greater Sandy Run area. Table 1-5 provides a breakdown of land uses within the developed portion of the facility.

Land use within MCB, Camp Lejeune is influenced by topography and ground cover, environmental policy, and base operational requirements. Much of the land within MCB, Camp Lejeune consists of freshwater swamps that are wooded and largely unsuitable for development. In addition, 3,000 acres of sensitive estuary and other areas set aside for the protection of threatened and endangered species are to remain undeveloped. Operational restrictions and regulations, such as explosive quantity safety distances, impact-weighted noise thresholds, and aircraft landing and clearance zones, may also greatly constrain and influence development (Master Plan, 1988).

The combined military and civilian population of the MCB, Camp Lejeune and Jacksonville area is approximately 112,000. Nearly 90 percent of the surrounding population resides within urbanized areas. The presence of MCB, Camp Lejeune has been the single greatest factor contributing to the rapid population growth of Jacksonville and adjacent communities, particularly during the period from 1940 to 1960.

1.2.10 Meteorology

Although coastal North Carolina lacks distinct wet and dry seasons, there is some seasonal variation in average precipitation. July tends to receive the most precipitation, and rainfall amounts during summer are generally the greatest. Daily showers during the summer are not uncommon, nor are periods of one or two weeks without rain. Convective showers and thunderstorms contribute to the variability of precipitation during the summer months. October tends to receive the least amount of precipitation, on average. Throughout the winter and spring precipitation occurs primarily in the form of migratory low pressure storms. MCB, Camp Lejeune's average yearly rainfall is 52.4 inches. Table 1-6 presents a climatic summary of data collected during 35 years (January 1955 to December 1990) of observations at MCAS, New River.

Coastal Plain temperatures are moderated by the proximity of the Atlantic Ocean, which effectively reduces the average daily fluctuation of temperature. Lying 50 miles offshore at its nearest point, the Gulf Stream tends to have little direct effect on coastal temperatures. The southern reaches of the cold Labrador Current offset any warming effect the Gulf Stream might otherwise provide.

MCB, Camp Lejeune experiences hot and humid summers; however, ocean breezes frequently produce a cooling effect. The winter months tend to be mild, with occasional brief cold spells. Average daily temperatures range from 34°F to 54°F in January, the coldest month, and 72°F to 89°F in July, the hottest month. The average relative humidity, between 78 and 89 percent, does not vary greatly from season to season.

Observations of sky conditions indicate yearly averages of approximately 112 days clear, 105 partly cloudy, and 148 cloudy. Measurable amounts of rainfall occur 118 days per year, on the average. Prevailing winds are generally from the south-southwest 10 months of the year and from the north-northwest during September and October. The average wind speed at MCAS, New River is seven miles per hour.

1.3 Background and Setting of Site 63

The following section provides both the location and setting of Site 63. A brief summary of past waste disposal activities at Site 63 is also provided within this section.

1.3.1 Site Location and Setting

The Verona Loop Dump (Site 63) is comprised of approximately five acres and is located nearly two miles south of the MCAS, New River operations area (see Figure 1-1). As Figure 1-5 depicts, vehicle access to the site is via Verona Loop Road, east from U.S. Route 17. The study area is located along Verona Loop Road approximately 1.25 miles from U.S. Route 17. Figure 1-6 presents a site map of the Verona Loop Dump. The site is bordered to the south by Verona Loop Road, to the east by an unnamed tributary to Mill Run, and to the west by a gravel access road.

Site 63 is relatively flat; however, the eastern portion slopes toward an intermittent stream along the boundary of the study area. The unnamed tributary that borders Site 63 to the east discharges into Mill Run approximately 2,000 feet south of Site 63. Mill Run then discharges into the Southwest Creek which eventually flows into the New River. A drainage ditch along Verona Loop Road receives surface water runoff from the extreme southern portion of the site and the asphalt road surface.

Much of the site is heavily vegetated with dense understory and trees greater than three inches in diameter. During the January 1995 RI scoping site visit an area of potentially impacted vegetation was tentatively identified by representatives of LANTDIV and Baker . Within this small area, several standing trees of less than three inches in diameter were observed without bark. During the November 1995 field investigation, however, the same area had begun to revegetate with small pines and hardwoods. A partially improved gravel road provides access to the main portion of the study area; other unimproved paths extend from this road. Several personnel entrenchments, used during training exercises, have been excavated throughout the study area. Earthen berms and small to medium size trees have been felled to construct protective works around many of the entrenchments.

1.3.2 Site History

Very little information is known regarding the history or occurrence of waste disposal practices at Site 63. The study area reportedly received wastes generated during training exercises. The types of material generated during these exercises is described by MCB, Camp Lejeune personnel as "bivouac" waste. Additional information suggests that no hazardous wastes were disposed of at Site 63. The years during which disposal operations may have taken place are not known.

The Verona Loop portion of MCB, Camp Lejeune (refer to Figure 1-1), which includes Site 63, is currently unrestricted to military personnel. Training exercises, maneuvers, and recreational hunting are frequently conducted in the area.

1.4 Previous Investigations

The following subsections describe previous investigation activities at OU No. 13, Site 63. These investigations include an Initial Assessment Study (IAS) and a Site Inspection (SI).

1.4.1 Initial Assessment Study

In 1983, an IAS was conducted at MCB, Camp Lejeune by Water and Air Research, Inc. (WAR). The IAS evaluated potential hazards at various sites throughout the facility, including Site 63. The IAS was based upon review of historical records, aerial photographs, a site visit, and personnel interviews. Conclusions from the IAS indicated that waste quantities at Site 63, regardless of their nature, were of a volume that did not require a Confirmation Study; therefore, additional investigations were not recommended for the study area at that time.

1.4.2 Site Inspection

In 1991, Baker conducted an SI at Site 63 to confirm findings of the IAS. The SI consisted of the following field activities: the installation and sampling of three monitoring wells (63-GW01, 63-GW02, and 63-GW03); the collection of two soil samples from each monitoring well test boring (one near the surface and one just above the water table); the collection of two soil samples from six additional soil borings; and the collection of two surface water and two sediment samples from the adjacent creek. Table 1-7 provides well construction details of the three shallow monitoring wells installed during the SI at Site 63. Figure 1-7 identifies the SI sampling locations.

Upon visual inspection of the site, conclusive indications (e.g., distressed vegetation, denuded areas, etc.) of hazardous waste disposal were not apparent; however, reinforced concrete rubble, construction material, and various other inert debris were identified during the SI and subsequent site visits. The observed waste material was limited to a number of distinct piles or areas, rather than being strewn throughout the study area.

The following paragraphs briefly describe the results and conclusions of the SI at Site 63. Tables 1-8 through 1-11 present summaries of laboratory analytical results from analysis performed on the samples collected during the SI.

1.4.2.1 Soil Investigation

The volatile organic compounds (VOCs) toluene and xylene were detected at concentrations of 2 and 3 μg/kg in a surface soil sample obtained from 63-SB03. No other volatile contaminants were detected among any of the samples obtained from either surface or subsurface soils. As provided in Table 1-8, concentrations of semivolatile organic compounds (SVOCs) ranged from 43 μg/kg of di-n-butylphthalate to 280 μg/kg of benzoic acid. The six soil samples obtained during installation of the three monitoring wells provided the only SVOC detections. The pesticides 4,4'-DDE, 4,4'-DDD, and 4,4'-DDT were detected at low concentrations in one surface sample obtained at location 63-SB04; no other pesticides were detected among the other soil samples. Aroclor-1254 was detected at a concentration of 1,000 µg/kg in a surface sample obtained from boring 63-SB02, located near the southern central portion of the study area. Figure 1-8 depicts SI sampling locations and concentrations of organic compounds detected among soil samples at Site 63.

Several inorganic analytes were also detected among the soil samples obtained at Site 63. The concentrations of the detected inorganic analytes were, for the most part, consistent with base-specific background levels. Table 1-8 presents positive detections of both organic and inorganic soil analytical results from the SI at Site 63.

1.4.2.2 Groundwater Investigation

Carbon disulfide, benzoic acid, and bis(2-ethylhexyl)phthalate were the only organic compounds detected in groundwater. Carbon disulfide was not detected in any other environmental media at Site 63. Aluminum, barium, chromium, lead, iron, and manganese (all total metals) were detected at concentrations which exceeded either federal Maximum Contaminant Levels (MCLs) or North Carolina Water Quality Standards (NCWQS). However, studies conducted at several sites throughout MCB, Camp Lejeune have also exhibited concentrations of total metals in excess of water quality standards. The results of these analyses tend to reflect the presence of suspended material in groundwater samples rather than depict true groundwater conditions. Table 1-9 presents a summary of the groundwater analytical results from the SI at Site 63. Figure 1-9 depicts the concentrations of both organic compounds and inorganic analytes detected among groundwater samples at Site 63.

1.4.2.3 Surface Water and Sediment Investigation

No organic compounds were detected among the two surface water and two sediment samples obtained from the unnamed creek that lies to the east of Site 63. A number of inorganic analytes were, however, detected among both the surface water and sediment samples. Iron was the only inorganic analyte detected at a concentration which exceeded applicable state or federal comparison criteria. Table 1-10 provides a summary of positive surface water detections.

Two sediment samples were also collected from the same sampling locations along the unnamed creek. Several inorganic analytes were detected including arsenic, chromium, copper, lead, nickel, and zinc. Only one detection each of copper and lead exceeded federal comparison criteria values. The sediment comparison values are based upon a potential to adversely impact aquatic life. The concentrations of copper and lead were within the "probable" adverse effects to biota range. Table 1-11 presents the sediment analytical results generated during the SI at Site 63.

1.4.2.4 Recommendations of the Site Inspection

Based on the findings of the SI, an RI/FS, including a human health and ecological risk assessment, was recommended to additionally evaluate the nature and extent of soil, sediment, surface water, and groundwater contamination. Further characterization of upgradient groundwater and background soil, surface water, and sediment was also recommended.

1.5 Remedial Investigation Objectives

The purpose of this section is to define the RI objectives that were intended to characterize past waste disposal activities at Site 63, assess potential impacts to public health and environment, and provide feasible alternatives for consideration during preparation of the ROD. The remedial objectives presented in this section have been identified through review and evaluation of existing background information, assessment of potential risks to public health and environment, and consideration of feasible remediation technologies and alternatives. As part of the remedial investigation at Site 63, soil, groundwater, surface water, and sediment investigations were conducted. The information gathered during these investigations was intended to fill previously existing data gaps and employed to generate human health and ecological risk values. Table 1-12 presents the RI objectives identified for Site 63. In addition, the table provides a general description of the study or investigation efforts that were conducted to obtain the requisite information.

1.6 References

Atlantic Division, Naval Facilities Engineering Command. January 1988. Camp Lejeune Complex Master Plan and Capital Improvements Plan Update. Prepared for the Commanding General, Marine Corps Base, Camp Lejeune, North Carolina.

Baker Environmental, Inc. January 1994. Site Inspection Report - Site 63, Verona Loop Dump. Final. Prepared for the Department of the Navy, Naval Facilities Engineering Command, Atlantic Division, Norfolk, Virginia.

Baker Environmental, Inc. September 1995. Remedial Investigation/Feasibility Study Work Plan for Operable Unit No. 13 (Site 63), Marine Corps Base Camp Lejeune, North Carolina. Final. Prepared for the Department of the Navy, Naval Facilities Engineering Command, Atlantic Division, Norfolk, Virginia.

Baker Environmental, Inc. September 1996. Site Management Plan for Marine Corps Base Camp Lejeune, North Carolina. Draft. Prepared for the Department of the Navy, Naval Facilities Engineering Command, Atlantic Division, Norfolk, Virginia.

Cardinell, A.P., Berg, S.A., and Lloyd, O.B. 1993. Hydrogeologic Framework of U.S. Marine Corps Base at Camp Lejeune, North Carolina: U.S. Geological Survey Water Resources Investigation Report. Report No. 93-4049.

Cowardin, Lewis M., Virginia Carter, Francis C. Golet, and Edward T. LaRoe. December 1979. Classification of Wetlands and Deepwater Habitats of the United States. Performed for U.S. Department of the Interior, Fish and Wildlife Service, Office of Biological Services - FWS/OBS-79/31.

Federal Facilities Agreement (FFA) Between United States Environmental Protection Agency, Region IV; the North Carolina Department of Environment, Health, and Natural Resources; and United States Department of the Navy for Marine Corps Base, Camp Lejeune and Marine Corps Air Station, New River, North Carolina. December 6, 1989.

Harned, D.A., Lloyd, O.B., Jr., and Treece, M.W., 1989. Assessment of Hydrologic and Hydrogeologic Data at Camp Lejeune Marine Corps Base, North Carolina: U.S. Geological Survey Water Resources Investigation. Report 89-4096, p. 64.

LeBlond, Richard J., John O. Fussell, and Alvin L. Broswell. February 1994. Inventory of Rare Species, Natural Communities, and Critical Areas of the Camp Lejeune Marine Corps Base, North Carolina. North Carolina Natural Heritage Program, Division of Parks and Recreation, Department of Environment, Health, and Natural Resources, Raleigh, North Carolina.

North Carolina Department of Environment, Health, and Natural Resources (NC DEHNR). May 1992. Interim Guidance for Wetlands Protection. Division of Environment, Water Quality Section.

U.S. Department of the Interior (USDI). March 1982. National Wetland Inventory Map, Camp Lejeune, North Carolina. Fish and Wildlife Service.

U.S. Marine Corps, MCB, Camp Lejeune (USMC). 1987. Multiple-Use Natural Resources Management Plan. Fish and Wildlife Division, Environmental Management Department, Marine Corps Base, Camp Lejeune, North Carolina.

Water and Air Research, Inc. (WAR) April 1983. Initial Assessment Study of Marine Corps Base Camp Lejeune, North Carolina. Prepared for the Department of the Navy, Naval Energy and Environmental Support Activity, Port Hueneme, California.

SECTION 1.0 TABLES

TABLE 1-1

GEOLOGIC AND HYDROGEOLOGIC UNITS OF NORTH CAROLINA'S COASTAL PLAIN REMEDIAL INVESTIGATION, CTO-0340 MCB, CAMP LEJEUNE, NORTH CAROLINA

<table>
<tr><th colspan="3">Geologic Units</th><th>Hydrogeologic Units</th></tr>
<tr><th>System</th><th>Series</th><th>Formation</th><th>Aquifer and Confining Unit</th></tr>
<tr><td>Quaternary</td><td>Holocene/Pleistocene</td><td>Undifferentiated</td><td>Surficial aquifer</td></tr>
<tr><td rowspan="10">Tertiary</td><td>Pliocene</td><td>Yorktown Formation[1]</td><td>Yorktown confining unit</td></tr>
<tr><td rowspan="4">Miocene</td><td>Eastover Formation[1]</td><td>Yorktown Aquifer</td></tr>
<tr><td rowspan="2">Pungo River Formation[1]</td><td>Pungo River confining unit</td></tr>
<tr><td>Pungo River Aquifer</td></tr>
<tr><td>Belgrade Formation[2]</td><td>Castle Hayne confining unit</td></tr>
<tr><td>Oligocene</td><td>River Bend Formation</td><td rowspan="2">Castle Hayne Aquifer</td></tr>
<tr><td rowspan="2">Eocene</td><td rowspan="2">Castle Hayne Formation</td></tr>
<tr><td>Beaufort confining unit[3]</td></tr>
<tr><td rowspan="2">Paleocene</td><td rowspan="2">Beaufort Formation</td><td>Beaufort Aquifer</td></tr>
<tr><td rowspan="2">Peedee confining unit</td></tr>
<tr><td rowspan="11">Cretaceous</td><td rowspan="9">Upper Cretaceous</td><td rowspan="2">Peedee Formation</td></tr>
<tr><td>Peedee Aquifer</td></tr>
<tr><td rowspan="3">Black Creek and Middendorf Formations</td><td>Black Creek confining unit</td></tr>
<tr><td>Black Creek Aquifer</td></tr>
<tr><td rowspan="2">Upper Cape Fear confining unit</td></tr>
<tr><td rowspan="4">Cape Fear Formation</td></tr>
<tr><td>Upper Cape Fear Aquifer</td></tr>
<tr><td>Lower Cape Fear confining unit</td></tr>
<tr><td>Lower Cape Fear Aquifer</td></tr>
<tr><td rowspan="2">Lower Cretaceous[1]</td><td rowspan="2">Unnamed deposits[1]</td><td>Lower Cretaceous confining unit</td></tr>
<tr><td>Lower Cretaceous Aquifer[1]</td></tr>
<tr><td colspan="2">Pre-Cretaceous basement rocks</td><td>--</td><td>--</td></tr>
</table>

Notes:

(1) Geologic and hydrologic units probably not present beneath MCB, Camp Lejeune.
(2) Constitutes part of the surficial aquifer and Castle Hayne confining unit in the study area.
(3) Estimated to be confined to deposits of Paleocene age in the study area.

Source: Harned et al., 1989.

TABLE 1-2

SUMMARY OF SURFICIAL AQUIFER HYDRAULIC PROPERTIES
UNRELATED SITE INVESTIGATIONS
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well No.	Hydraulic Conductivity Falling Head Test		Hydraulic Conductivity Rising Head Test		Transmissivity	Storativity
	ft/day	cm/sec	ft/day	cm/sec	gal/day/ft	
MW-30A	1.18	4.16E-04	1.5	5.31E-04	--	--
MW-31A	0.346	1.22E-04	0.269	9.51E-05	--	--
MW-35A	0.119	4.20E-05	0.116	4.06E-05	--	--
MW-32B	6.22	2.20E-03	5.15	1.82E-03	--	--
MW-36B	2.91	1.03E-03	3.2	1.13E-03	--	--
MW-37B	7.06	2.49E-03	6.44	2.27E-03	--	--
GWD-1	6.8	2.40E-03	6.03	2.13E-03	--	--
122MW-3	0.25	8.80E-05	0.015	5.30E-06	--	--
122MW-5	0.47	1.70E-04	0.034	1.20E-05	--	--
122MW-12	0.068	2.40E-05	0.0085	3.00E-06	--	--
MW-13(1)	0.0554	1.96E-05	0.0032	1.13E-06	--	--
MW-14(1)	0.188	6.62E-05	7.26E-04	2.56E-07	--	--
MW-3(2)	--	--	0.75	2.60E-04	--	--
MW-4(2)	--	--	0.27	9.50E-05	--	--
MW-11(2)	--	--	0.37	1.30E-04	--	--
MW-21(2)	--	--	0.46	1.60E-04	5.5	0.028
RW-1(2)	--	--	--	--	54	--
MW-18(2)	--	--	--	--	790	0.014

Notes:

All data compiled from unrelated Baker Investigations with the MCAS, New River operations area.

(1) AS 527
(2) Campbell Street Fuel Farm
A = Upper Surficial Aquifer
B = Lower Surficial Aquifer

TABLE 1-3

HYDRAULIC PROPERTY ESTIMATES OF THE CASTLE HAYNE AQUIFER AND CONFINING UNIT
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Hydraulic Properties	USGS Phase I Study[1]	USGS Aquifer Test[2]	ESE, Inc. [3]	DEHNR Aquifer Test[4]	RASA Estimate[5]
Aquifer transmissivity (cubic foot per day per square foot times foot of aquifer thickness)	4,300 to 24,500 average 9,500	1,140 to 1,325	820 to 1,740 average 1,280	900	10,140 to 26,000
Aquifer hydraulic conductivity (foot per day)	14 to 82 average 35	20 to 60	--	18 to 91 average 54	45 to 80 average 65
Aquifer storage coefficient (dimensionless)	--	2.0×10^{-4} to 2.2×10^{-4}	5.0×10^{-4} to 1.0×10^{-3} average 8.0×10^{-4}	1.9×10^{-3}	--
Confining-unit vertical hydraulic conductivity (foot per day)	--	3.0×10^{-2} to 4.1×10^{-1}	1.4×10^{-3} to 5.1×10^{-2} average 3.5×10^{-3}	--	--

Notes:

(1) Analysis of specific capacity data from Harned and others (1989).
(2) Aquifer test at well HP-708.
(3) Aquifer test at Hadnot Point well HP-462 from Environmental Sciences and Engineering, Inc. (1988).
(4) Unpublished aquifer test data at well X24s2x, from DEHNR well records (1985).
(5) Transmissivities based on range of aquifer thickness and average hydraulic conductivity from Winner and Coble (1989).

Source: Cardinell, et al., 1993.

TABLE 1-4

PROTECTED SPECIES WITHIN MCB, CAMP LEJEUNE
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Species	Protected Classification
Animals:	
American alligator (Alligator mississippienis)	SC
Bachmans sparrow (Aimophilia aestivalis)	FCan, SC
Green (Atlantic) turtle (Chelonia m. mydas)	T(f), T(s)
Loggerhead turtle (Caretta caretta)	T(f), T(s)
Peregrine falcon (Falco peregrinus)	E(f), (E(s)
Piping plover (Charadrius melodus)	T(f), T(s)
Red-cockaded woodpecker (Picoides borealis)	E(f), E(s)
Southern Hognose Snake (Heterodon simus)	FCan, SR
Diamondback Terrapin (Malaclemys terrapin)	FCan, SC
Carolina Gopher Frog (Rana capito capito)	FCan, SC
Cooper's Hawk (Accipiter cooperii)	SC
Eastern Diamondback Rattlesnake (Crotalus adamanteus)	SR
Eastern Coral Snake (Micrurus fulvius)	SR
Pigmy Rattlesnake (Sistrurus miliarius)	SR
Black Bear (Ursus americanus)	SR
Plants:	
Rough-leaf loosestrife (Lysimachia asperulifolia)	E(f), E(s)
Seabeach Amaranth (Amaranthus pumilus)	T(f). T(s)
Chapman's Sedge (Carex chapmanii)	FCan
Hirst's Witchgrass (Dichanthelium sp.)	FCan
Pondspice (Litsea aestivalis)	FCan
Boykin's Lobelia (Lobelia boykinii)	FCan
Loose Watermilfoil (Myriophyllum laxum)	FCan,T(s)
Awned Meadowbeauty (Rhexia aristosa)	FCan,T(s)
Carolina Goldenrod (Solidago pulchra)	FCan, E(s)
Carolina Asphodel (Tofieldia glabra)	FCan
Venus Flytrap (Dionaea muscipula)	FCan
Flaxleaf Gerardia (Agalinis linifolia)	SR
Pinebarrens Goober Grass (Amphicarpum purshii)	SR
Longleaf Three-awn (Aristida palustris)	SR
Pinebarrens Sandreed (Calamovilfa brevipilis)	E(s)
Warty Sedge (Carex verrucosa)	SR
Smooth Sawgrass (Cladium mariscoides)	SR
Leconte's Flatsedge (Cyperus lecontei)	SR
Erectleaf Witchgrass (Dichanthelium erectifolium)	SR
Horsetail Spikerush (Eleocharis equisetoides)	SR
Sand Spikerush (Eleocharis montevidensis)	SR

TABLE 1-4 (Continued)

PROTECTED SPECIES WITHIN MCB, CAMP LEJEUNE
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Species	Protected Classification
Flaxleaf Seedbox (Ludwigia linifolia)	SR
Torrey's Muhley (Muhlenbergia torreyana)	E(s)
Southeastern Panic Grass (Panicum tenerum)	SR
Spoonflower (Peltandra sagittifolia)	SR
Shadow-witch (Ponthieva racemosa)	SR
West Indies Meadowbeauty (Rhexia cubensis)	SR
Pale Beakrush (Rhynchospora pallida)	SR
Longbeak Baldsedge (Rhynchospora scirpoides)	SR
Tracy's Beakrush (Rhynchospora tracyi)	SR
Canby's Bulrush (Scirpus etuberculatus)	SR
Slender Nutrush (Scleria minor)	SR
Lejeune Goldenrod (Solidago sp.)	SR
Dwarf Bladderwort (Utricularia olivacea)	T(s)
Elliott's Yellow-eyed Grass (Xyris elliottii)	SR
Carolina Dropseed (Sporobolus sp.)	T(s)

Legend:
E(f) = Federal Endangered
T(f) = Federal Threatened
Fcan = Candidate for Federal Listing
E(s) = State Endangered
T(s) = State Threatened
SC = State Special Concern
SR = State Rare

Source: LeBlond, 1994

TABLE 1-5

LAND UTILIZATION WITHIN DEVELOPED AREAS OF MCB, CAMP LEJEUNE
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Geographic Area	Operation	Training (Instruc.)	Maintenance	Supply/ Storage	Medical	Admin-istration	Family Housing	Troop Housing	CM	CO	Recreation	Utility	Total
Hadnot Point	31 (2.9)	15 (1.4)	154 (14.3)	157 (14.4)	10 (0.9)	122 (11.3)	22 (2.0)	196 (18.1)	115 (10.7)	36 (3.3)	182 (16.9)	40 (3.7)	1,080 (100)
Paradise Point	1 (0)		3 (0.4)	1 (0)			343 (34)	19 (1.9)	31 (3.1)		610 (60.4)	2 (0.2)	1,010 (100)
Berkeley Manor/ Watkins							406 (80)		41 (8.1)	1 (0.2)	57 (11.2)	2 (0.5)	507 (100)
Midway Park		1 (0.4)		2 (0.7)		2 (0.7)	248 (92.2)		8 (3.0)	3 (1.1)	4 (1.5)	1 (0.4)	269 (100)
Tarawa Terrace I and II			3 (0.5)			1 (0.3)	428 (77.4)		55 (9.9)	11 (2.0)	47 (8.5)	8 (1.4)	553 (100)
Knox Trailer							57 (100)						
French Creek	8 (1.4)	1 (0.2)	74 (12.7)	266 (45.6)	3 (0.5)	7 (1.2)		122 (20.9)	22 (3.8)	6 (1.0)	74 (12.7)		583 (100)
Courthouse Bay		73 (28.6)	28 (10.9)	14 (5.5)		12 (4.7)	12 (4.7)	43 (16.9)	15 (5.9)	4 (1.6)	43 (16.9)	11 (4.3)	255 (100)
Onslow Beach	6 (9.8)	1 (1.6)	3 (4.8)	2 (3.2)	1 (1.6)	2 (3.2)		2 (3.2)	12 (19.3)		25 (40.3)	8 (13.0)	62 (100)
Rifle Range		1 (1.3)	1 (1.3)	7 (8.8)	1 (1.3)	5 (6.3)	7 (8.8)	30 (37.5)	5 (6.3)	1 (1.3)	9 (11.3)	13 (16.3)	80 (100)
Camp Geiger	4 (1.9)	15 (6.9)	19 (8.8)	50 (23.1)		23 (10.6)		54 (25.0)	27 (12.5)	2 (1.0)	16 (7.4)	6 (2.8)	216 (100)
Montford Point	6 (2.6)	48 (20.5)	2 (0.9)	4 (1.7)	2 (0.9)	9 (3.9)		82 (35.2)	20 (8.6)	1 (0.4)	49 (21.0)	10 (4.3)	233 (100)
Base-Wide Misc.	1 (0.8)			87 (68.0)		3 (2.3)			19 (14.8)			18 (14.1)	128 (100)
TOTAL	**57** **(1.)**	**155** **(3.1)**	**287** **(5.7)**	**590** **(11.7)**	**17** **(0.38)**	**186** **(3.7)**	**1,523** **(30.2)**	**548** **(10.8)**	**370** **(7.4)**	**65** **(1.3)**	**1,116** **(22.2)**	**119** **(2.4)**	**5,033** **(100)**

Notes:

Numbers without parentheses represent total acres.
Numbers within parentheses represent percentage of total acres.
Source: Master Plan, 1988

TABLE 1-6

CLIMATIC DATA SUMMARY
MARINE CORPS AIR STATION, NEW RIVER
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

	Precipitation (Inches)			Relative Humidity (Percent)	Temperature (Fahrenheit)			Mean Number of Days With				
								Precipitation		Temperature		
	Maximum	Minimum	Average		Maximum	Minimum	Average	>=0.01"	>=0.5"	>=90F	>=75F	<=32F
January	7.5	1.4	4.0	79	54	34	44	11	2	0	1	16
February	9.1	.9	3.9	78	57	36	47	10	3	0	2	11
March	8	.8	3.9	80	64	43	54	10	3	*	5	5
April	8.8	.5	3.1	79	73	51	62	8	2	1	13	*
May	8.4	.6	4.0	83	80	60	70	10	3	2	25	0
June	11.8	2.2	5.2	84	86	67	77	10	4	7	29	0
July	14.3	4.0	7.7	86	89	72	80	14	5	13	31	0
August	12.6	1.7	6.2	89	88	71	80	12	4	11	31	0
September	12.8	.8	4.6	89	83	66	75	9	3	4	27	0
October	8.9	.6	2.9	86	75	54	65	7	2	*	17	*
November	6.7	.6	3.2	83	67	45	56	8	2	0	7	3
December	6.6	.4	3.7	81	58	37	48	9	2	0	2	12
Annual	65.9	38.2	52.4	83	73	53	63	118	35	39	189	48

Notes:

* = Mean no. of days less than 0.5 days

Source: Naval Oceanography Command Detachment, Asheville, North Carolina. Measurements obtained from January 1955 to December 1990.

TABLE 1-7

SUMMARY OF WELL CONSTRUCTION DETAILS
SITE INSPECTION
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well No.	Date Installed	Top of PVC Casing Elevation (feet, above msl)[(1)]	Ground Surface Elevation (feet, above msl)	Boring Depth (feet, below ground surface)	Well Depth (feet, below ground surface)	Screen Interval Depth (feet, below ground surface)	Sand Pack Interval Depth (feet, below ground surface)	Bentonite Interval Depth (feet, below ground surface)
63-GW01	8/8/91	49.01	46.0	15	14.0	4.0 - 14.0	2.5 - 15.0	1.8 - 2.5
63-GW02	8/7/91	45.90	42.6	14	13.0	3.0 - 13.0	2.0 - 14.0	1.1 - 2.0
63-GW03	8/8/91	45.03	41.8	14	13.2	3.2 - 13.2	2.5 - 14.0	1.6 - 2.5

Notes:

Horizontal positions are referenced to N.C. State Plane Coordinate System (NAD 27) CF = 0.9999216 from USMC Monument Toney.
Vertical datum NGVD 29.
(1) msl = mean sea level

TABLE 1-8

POSITIVE DETECTIONS IN SOIL
SITE INSPECTION, 1991
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Organics	Surface Soil (0-2 feet)			Subsurface Soil (below 2 feet)		
	Detection Frequency	Range of Positive Detections (µg/kg)	Location of Maximum Concentration	Detection Frequency	Range of Positive Detections (µg/kg)	Location of Maximum Concentration
Toluene	1/9	2	SB03	0/9	ND	NA
Total Xylenes	1/9	3	SB03	0/9	ND	NA
Benzoic Acid	2/9	45-280	MW02	0/9	ND	NA
Di-n-butylphthalate	3/9	43-51	MW01	2/9	43-78	MW02
bis(2-Ethyhexyl) phthalate	3/9	44-72	MW02	1/9	62	MW01
4-4'-DDE	1/9	58	SB04	0/9	ND	NA
4-4'-DDD	1/9	53	SB04	0/9	ND	NA
4-4'-DDT	1/9	39	SB04	0/9	ND	NA
Aroclor-1254	1/9	1000	SB02	0/9	ND	NA

TABLE 1-8 (Continued)

POSITIVE DETECTIONS IN SOIL
SITE INSPECTION, 1991
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Inorganics	Surface Soil (0-2 feet)			Subsurface Soil (below 2 feet)		
	Detection Frequency	Range of Positive Detections (mg/kg)	Location of Maximum Concentration	Detection Frequency	Range of Positive Detections (mg/kg)	Location of Maximum Concentration
Aluminum	8/9	975-8,450	SB01	9/9	1,920-20,500	SB04
Arsenic	4/9	1.4-2.3	SB03	5/9	1.3-9.1	SB06
Barium	3/9	16.9-22.9	SB04	3/9	16.3-41.8	SB04
Calcium	0/9	ND	NA	3/9	79.7-377.0	SB04
Chromium	8/9	1.7-11.3	SB03	9/9	2.0-30.3	SB04
Copper	8/9	2.3-20.3	SB05	9/9	2.9-24.0	SB04
Iron	8/9	741-5980	SB03	9/9	682-16,100	SB01
Lead	8/9	2.2-36.3	SB04	9/9	2.1-8.5	SB04
Magnesium	7/9	32.2-324.0	SB01	9/9	40.9-1020.0	SB04
Manganese	7/9	6.6-22.8	SB04	8/9	4.9-57.1	SB04
Nickel	5/9	2.1-3.9	SB01	7/9	2.2-7.3	SB04
Potassium	4/9	373-697	SB03	7/9	290-2,000	SB04
Vanadium	8/9	2.2-13.8	SB03	9/9	1.6-36.9	SB04
Zinc	6/9	8.4-57.1	SB04	7/9	6.6-33.9	SB04

Notes:

µg/kg - micrograms per kilogram
mg/kg - milligrams per kilogram
ND - not detected
NA - not applicable

TABLE 1-9

POSITIVE DETECTIONS IN GROUNDWATER
SITE INSPECTION, 1991
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Detection Frequency	Range of Positive Detections (µg/L)	Location of Maximum Concentration	Comparison Criteria	
				USEPA MCL (µg/L)	State Standard (µg/L)
Carbon Disulfide	2/3	1	MW01, MW02	--	0.7
Benzoic Acid	1/3	3	MW02	--	--
bis(2-Ethylhexyl)phthalate	1/3	9	MW02	--	--
Aluminum	3/3	3,650-85,300	MW02	0.05 - 0.2	--
Barium	3/3	56.1-5,410	MW02	2,000	2,000
Chromium	3/3	4.4-134	MW02	100	50
Iron	3/3	4,320-100,000	MW02	300	300
Lead	3/3	4.3-369	MW02	15(1)	15
Manganese	3/3	50.3-1,020	MW02	50	50

Notes:

µg/L - microgram per liter
(1) USEPA "action level" for lead

TABLE 1-10

POSITIVE DETECTIONS IN SURFACE WATER
SITE INSPECTION, 1991
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Detection Frequency	Range of Positive Detections (µg/L)	FWQSV/ NCWQS (µg/L)
Aluminum	2/2	1,030-1,170	--
Barium	2/2	26.9-34.8	--/1,000
Calcium	2/2	1,570-2,520	--
Copper	1/2	6.3	6.54/7.0
Iron	2/2	1,040-1,090	--/1,000
Magnesium	2/2	746-845	--
Manganese	2/2	10.4-13.6	--/200
Nickel	1/2	10.2	88/25
Sodium	2/2	4,150-4,780	--
Thallium	1/2	2.0	--

Notes:

µg/L - micrograms per liter
FWQSV - Fresh Water Quality Screening Value (USEPA Region IV, 1994).
NCWQS - North Carolina Water Quality Standard for fresh water aquatic life or more stringent standard to support additional uses.

TABLE 1-11

POSITIVE DETECTIONS IN SEDIMENT
SITE INSPECTION, 1991
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Detection Frequency	Range of Positive Detections (mg/kg)	Effects Range Low[1] (mg/kg)
Aluminum	2/2	803-13,400	--
Arsenic	1/2	3.5	8.2
Barium	2/2	2.7-34.2	--
Beryllium	1/2	0.31	--
Calcium	1/2	160	--
Chromium	2/2	1.7-17.3	81
Copper	2/2	16.8-76.8	34
Iron	2/2	376-5750	--
Lead	2/2	3.4-90.0	46.7
Magnesium	2/2	36.5-525	--
Manganese	2/2	2.7-14.7	--
Nickel	2/2	3.5-8.2	20.9
Potassium	1/2	873	--
Vanadium	2/2	1.6-24.0	--
Zinc	2/2	3.5-19.0	150

Notes:

mg/kg - milligrams per kilogram
[1] Region IV - Effects Range Low from Long, et. al., 1995.

TABLE 1-12

OPERABLE UNIT NO. 13 (SITE 63)
REMEDIAL INVESTIGATION/FEASIBILITY STUDY OBJECTIVES - CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Medium or Area of Concern	RI/FS Objective	Criteria for Meeting Objective	Proposed Investigation/Study
1. Soil	1a. Assess the nature and extent of soil contamination within and surrounding the suspected disposal area.	Characterize contaminant levels in surface and subsurface soils within the suspected disposal area.	Soil Investigation
	1b. Assess human health and ecological risks associated with exposure to surface soils at the site.	Characterize contaminant levels in surface soils within the study area.	Soil Investigation Risk Assessment
	1c. Determine whether contamination from soils is migrating to groundwater.	Characterize subsurface soil. Characterize shallow groundwater.	Soil Investigation Groundwater Investigation
2. Groundwater	2a. Assess human health risks posed by potential future usage of the shallow groundwater.	Evaluate groundwater quality and compare to groundwater criteria and risk-based action levels.	Groundwater Investigation Risk Assessment
	2b. Assess nature of shallow groundwater quality.	Characterize shallow groundwater quality.	Groundwater Investigation
	2c. Define hydrogeologic characteristics for fate and transport evaluation and remedial technology evaluation, if required.	Estimate hydrogeologic characteristics of the shallow aquifer (flow direction, transmissivity, permeability, etc.).	Groundwater Investigation
3. Surface Water and Sediment	3a. Assess human health and ecological risks associated with exposure to surface water and sediment in adjacent creek.	Characterize nature and extent of contamination in surface water and sediment.	Surface Water and Sediment Investigation Risk Assessment
	3b. Determine extent of sediment contamination for purposes of identifying areas of concern.	Identify extent of surface water and sediment contamination.	Surface Water and Sediment Investigation

SECTION 1.0 FIGURES

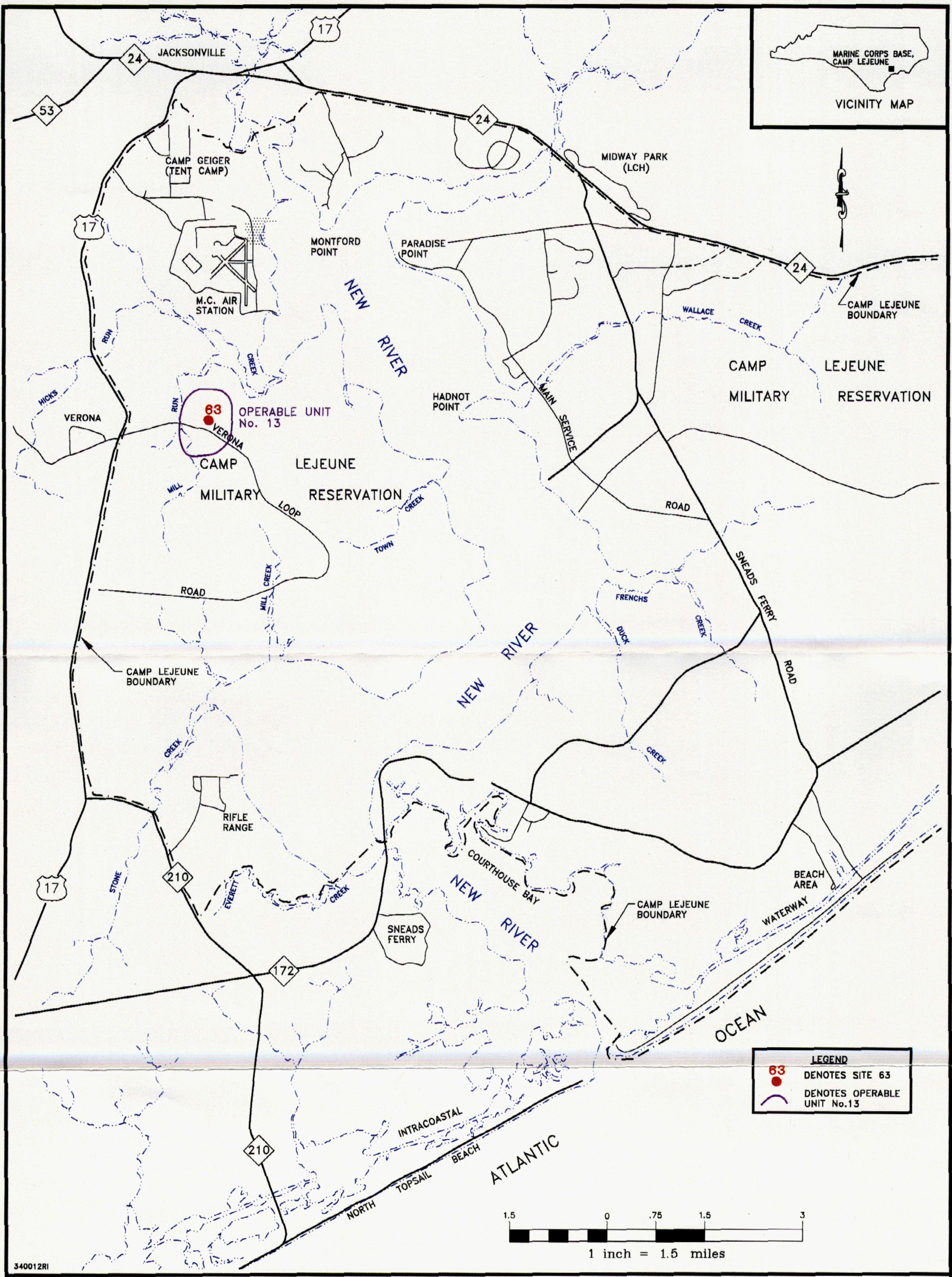


FIGURE 1-1
OPERABLE UNIT 13 - SITE 63
REMEDIAL INVESTIGATION, CTO-0340

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01708N04Y

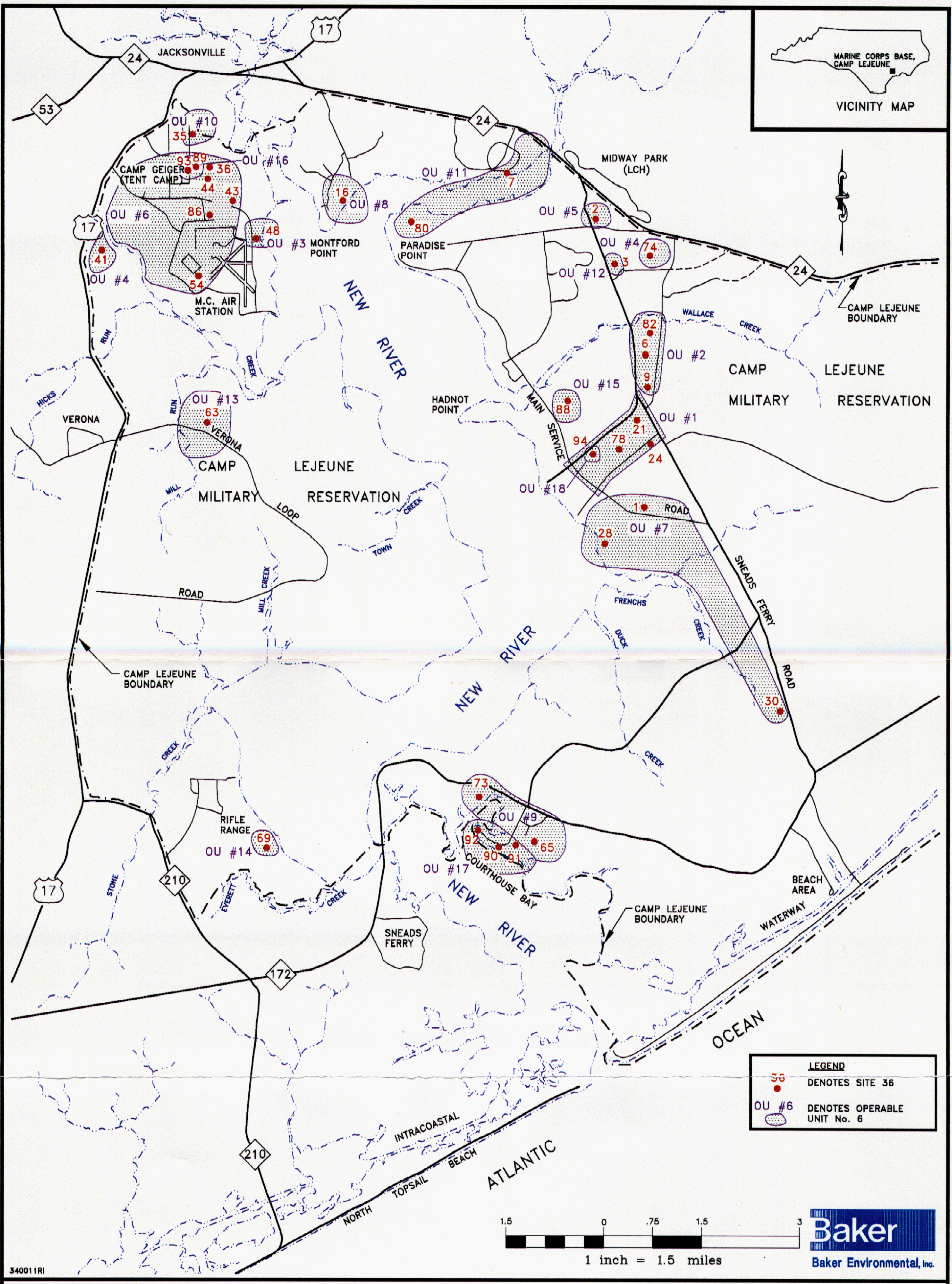
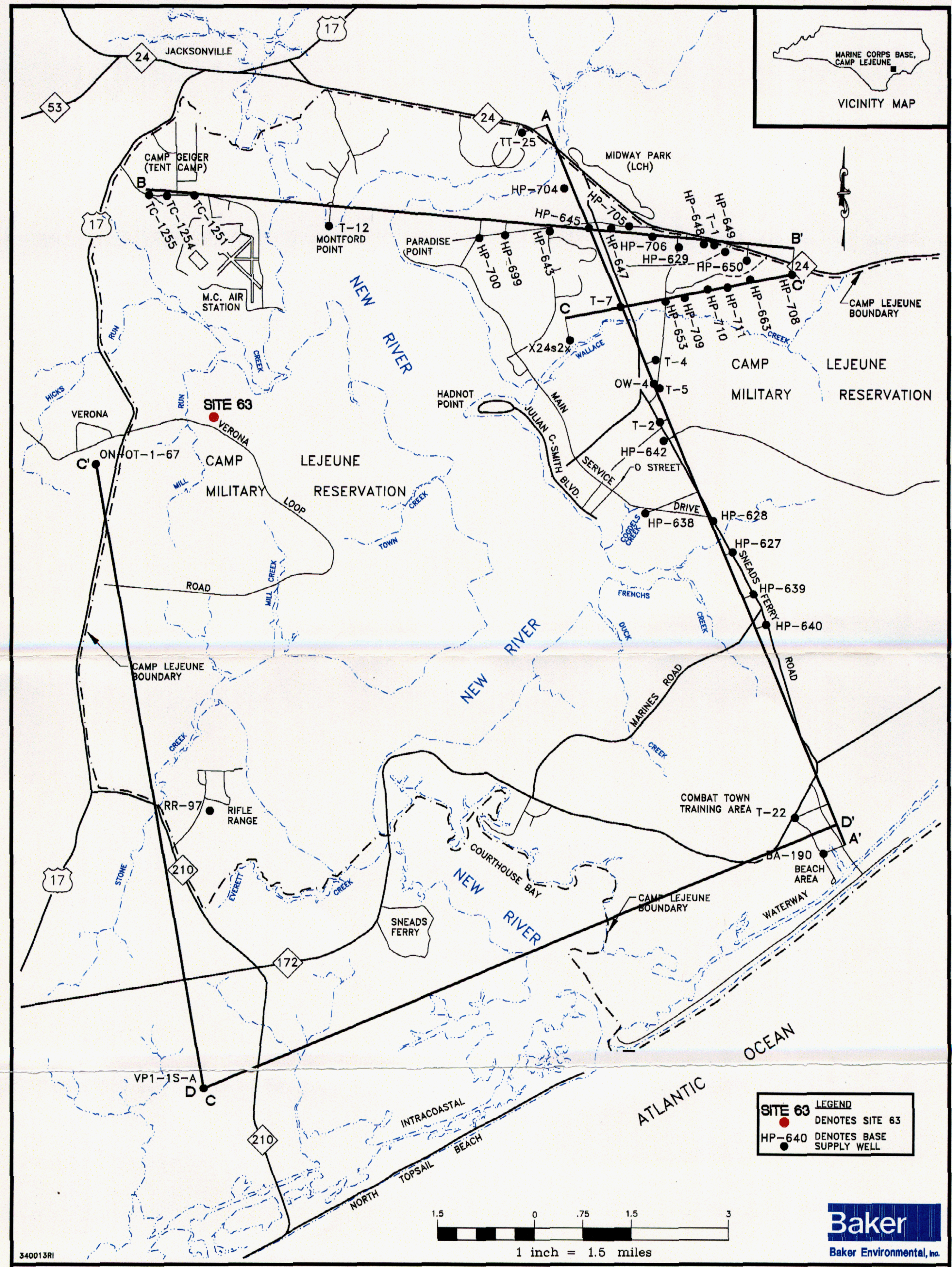


FIGURE 1-2
OPERABLE UNIT AND SITE LOCATIONS
REMEDIAL INVESTIGATION, CTO-0340

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01708N05Y



SOURCE: DEPT. OF INTERIOR, WATER-RESOURCES INVESTIGATIONS REPORT, 89-4096, PLATE 4

FIGURE 1-3
LOCATIONS OF HYDROGEOLOGIC CROSS-SECTIONS
REMEDIAL INVESTIGATION, CTO-0340

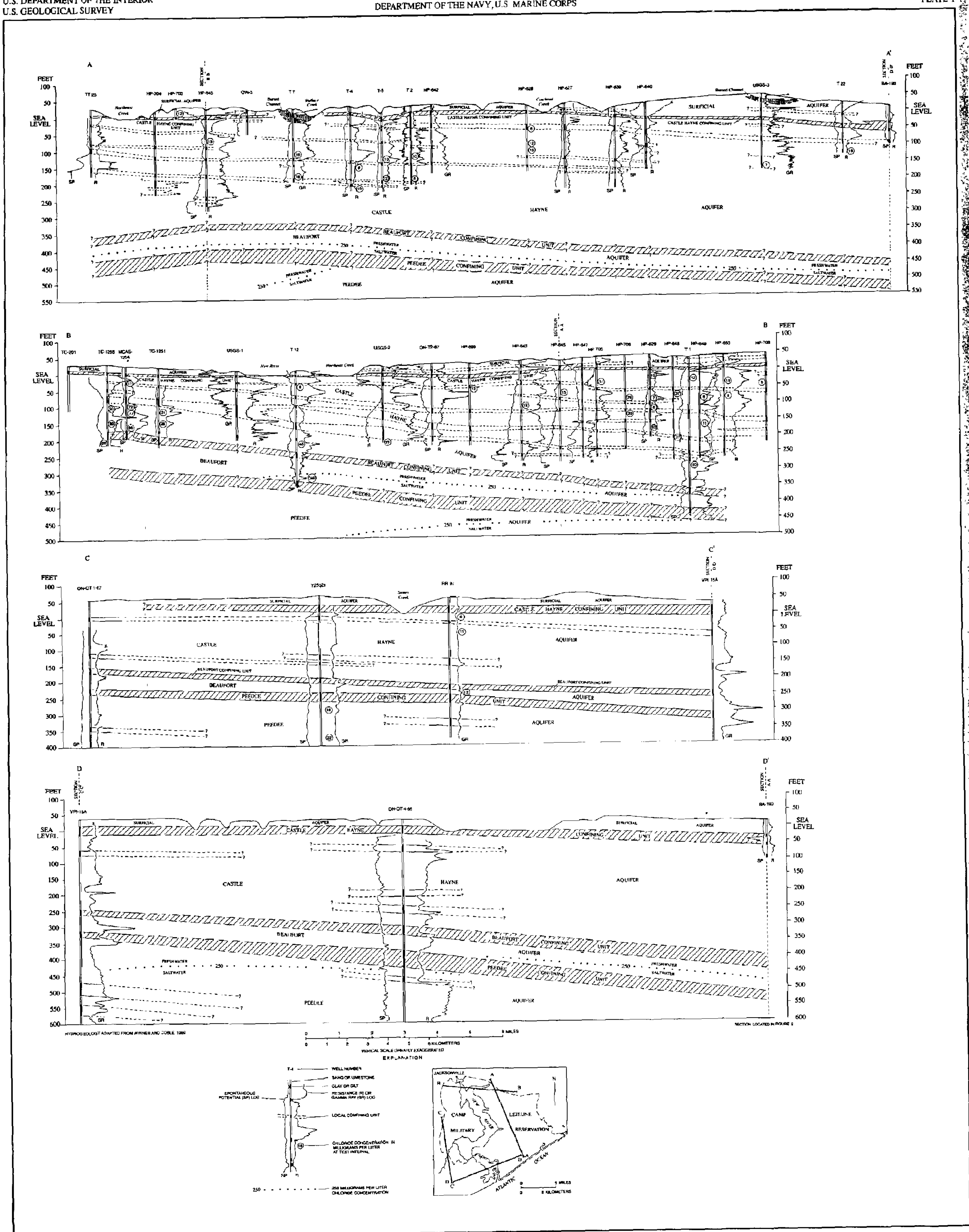
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01708N06Y

U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Prepared in cooperation with the
DEPARTMENT OF THE NAVY, U.S MARINE CORPS

WATER-RESOURCES INVESTIGATIONS REPORT 93-4049
PLATE 1



HYDROGEOLOGIC SECTIONS A-A', B-B', C-C', AND D-D' AT CAMP LEJEUNE, NORTH CAROLINA

By
Alex P. Cardinell, Steven A. Berg, and Orville B. Lloyd, Jr.
1993

REVISIONS	DRAWN REL REVIEWED TFT S O # 62470-340-0000-07000 CADD# 340030RI	REMEDIAL INVESTIGATION, CTO-0340 MARINE CORPS BASE, CAMP LEJEUNE NORTH CAROLINA BAKER ENVIRONMENTAL, Inc. Coraopolis, Pennsylvania	Baker Baker Environmental, Inc.	HYDROGEOLOGIC CROSS-SECTION SCALE AS SHOWN DATE SEPTEMBER 1996	FIGURE NO 1-4

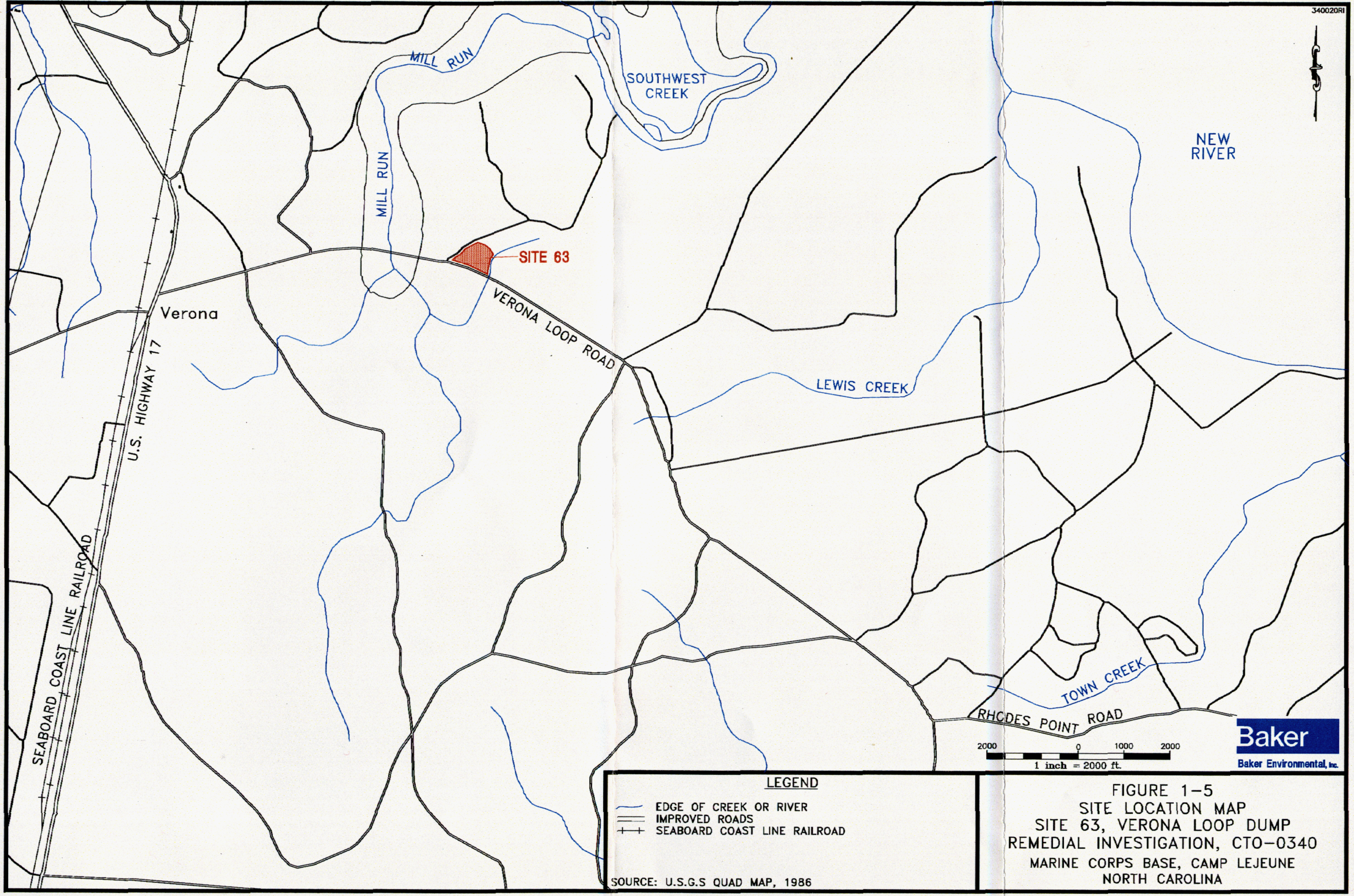


FIGURE 1-5
SITE LOCATION MAP
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01708N08Y

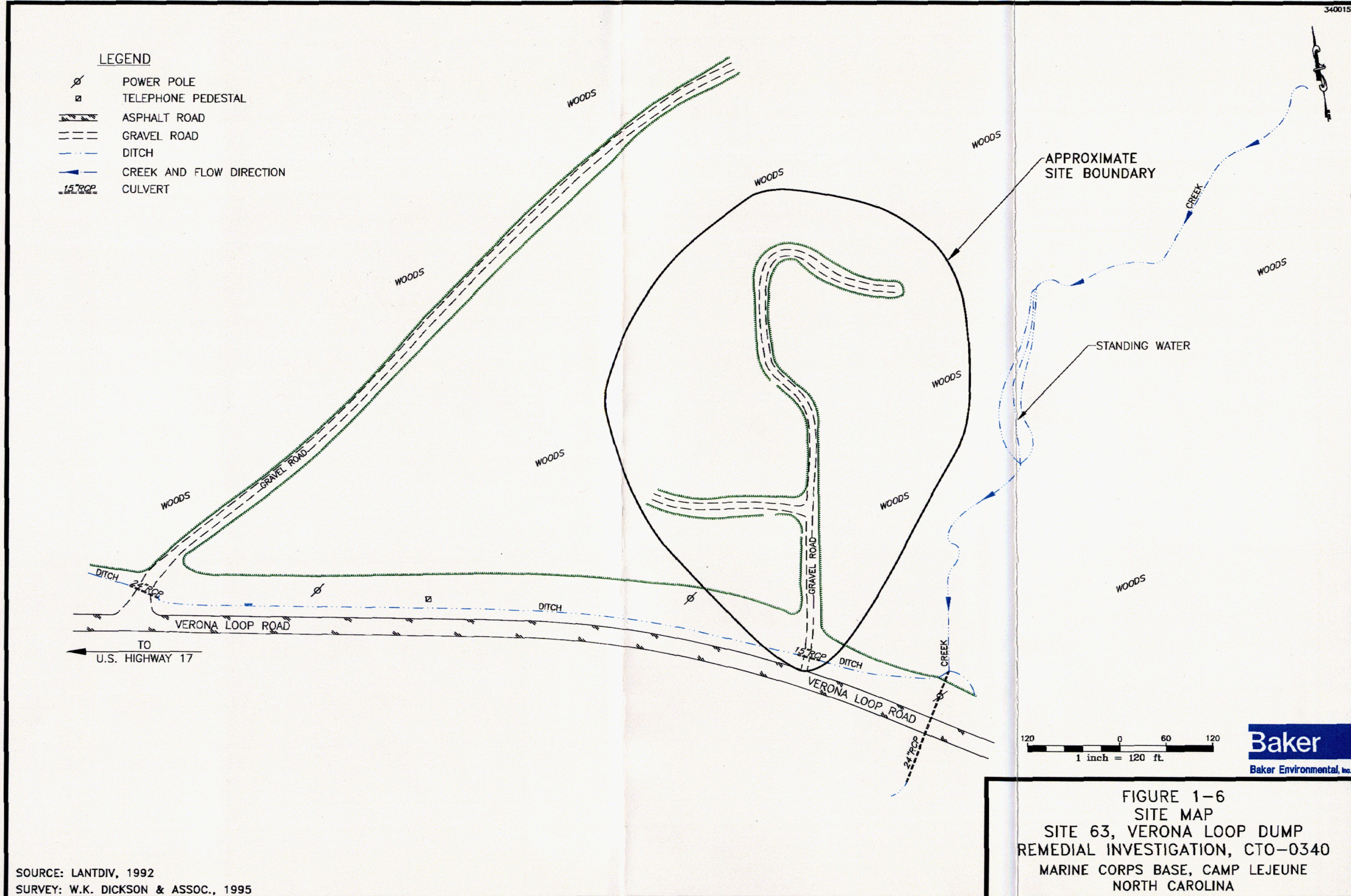
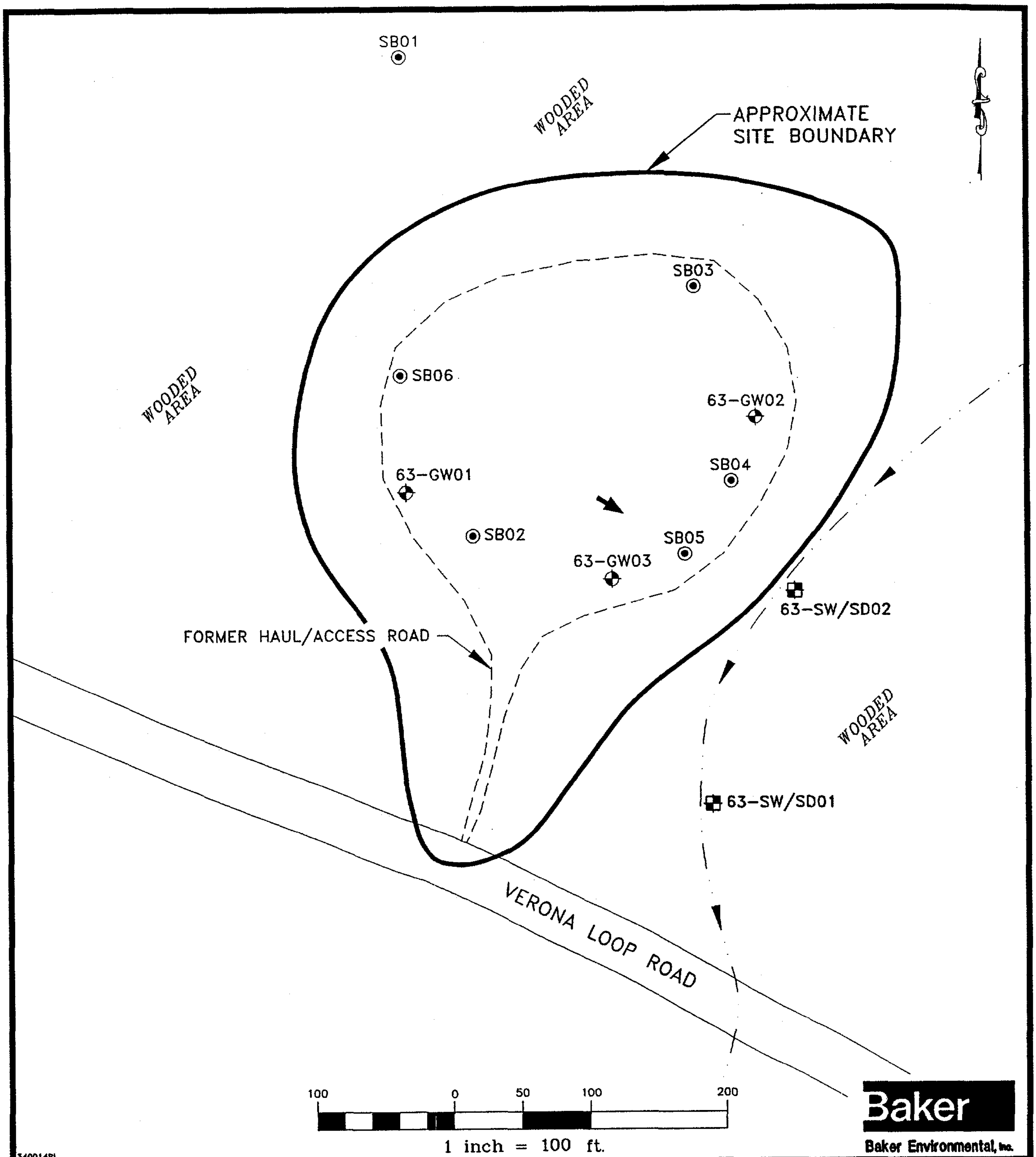


FIGURE 1-6
SITE MAP
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01708N09Y

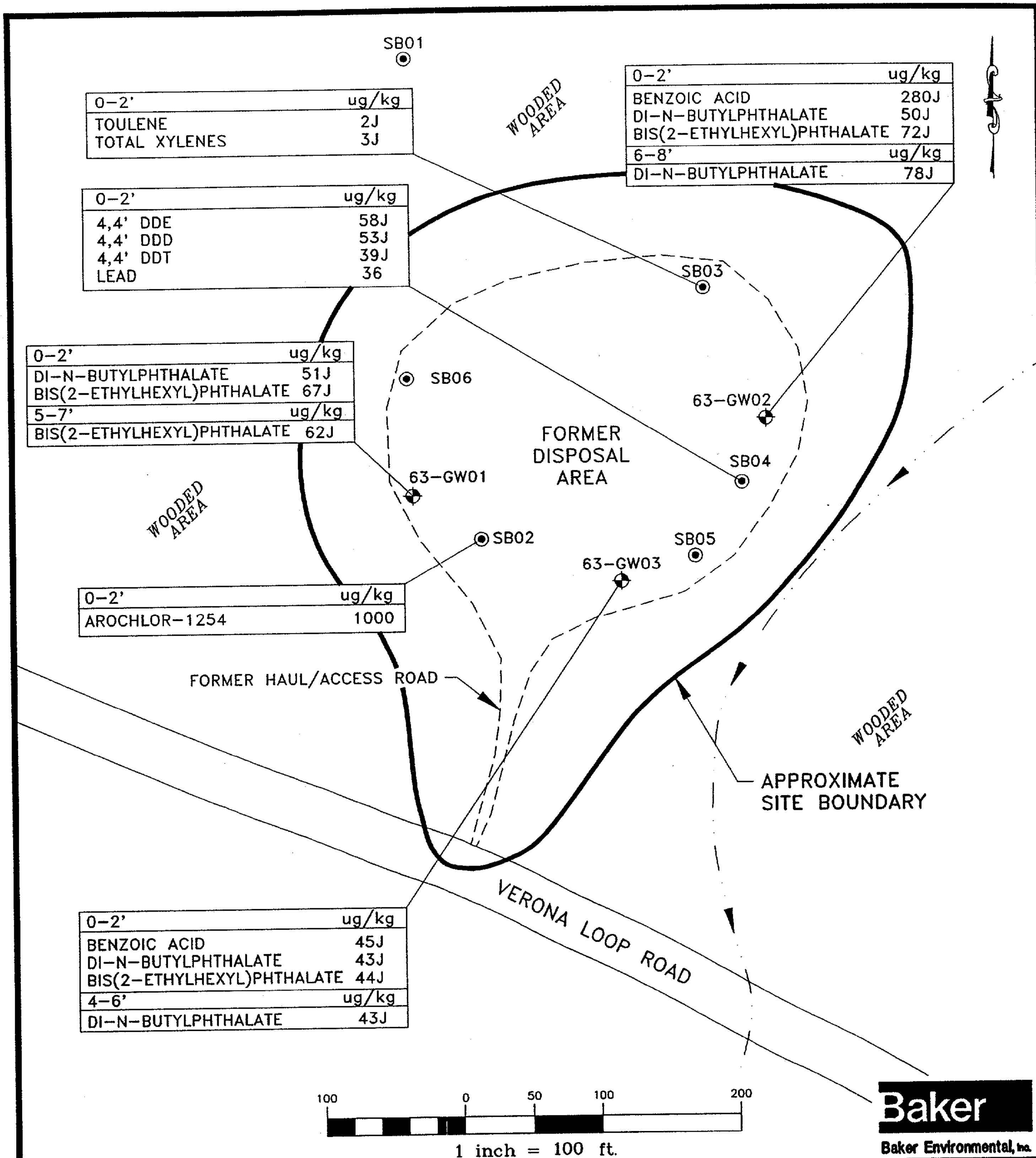


LEGEND

- SURFACE WATER AND SEDIMENT SAMPLE LOCATION
- APPROXIMATE GROUNDWATER FLOW DIRECTION
- SOIL TEST BORING
- SHALLOW GROUNDWATER MONITORING WELL
- APPROXIMATE LOCATION AND FLOW DIRECTION OF INTERMITTENT STREAM

FIGURE 1-7
SITE INSPECTION SAMPLING LOCATIONS
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

◉ SOIL TEST BORING

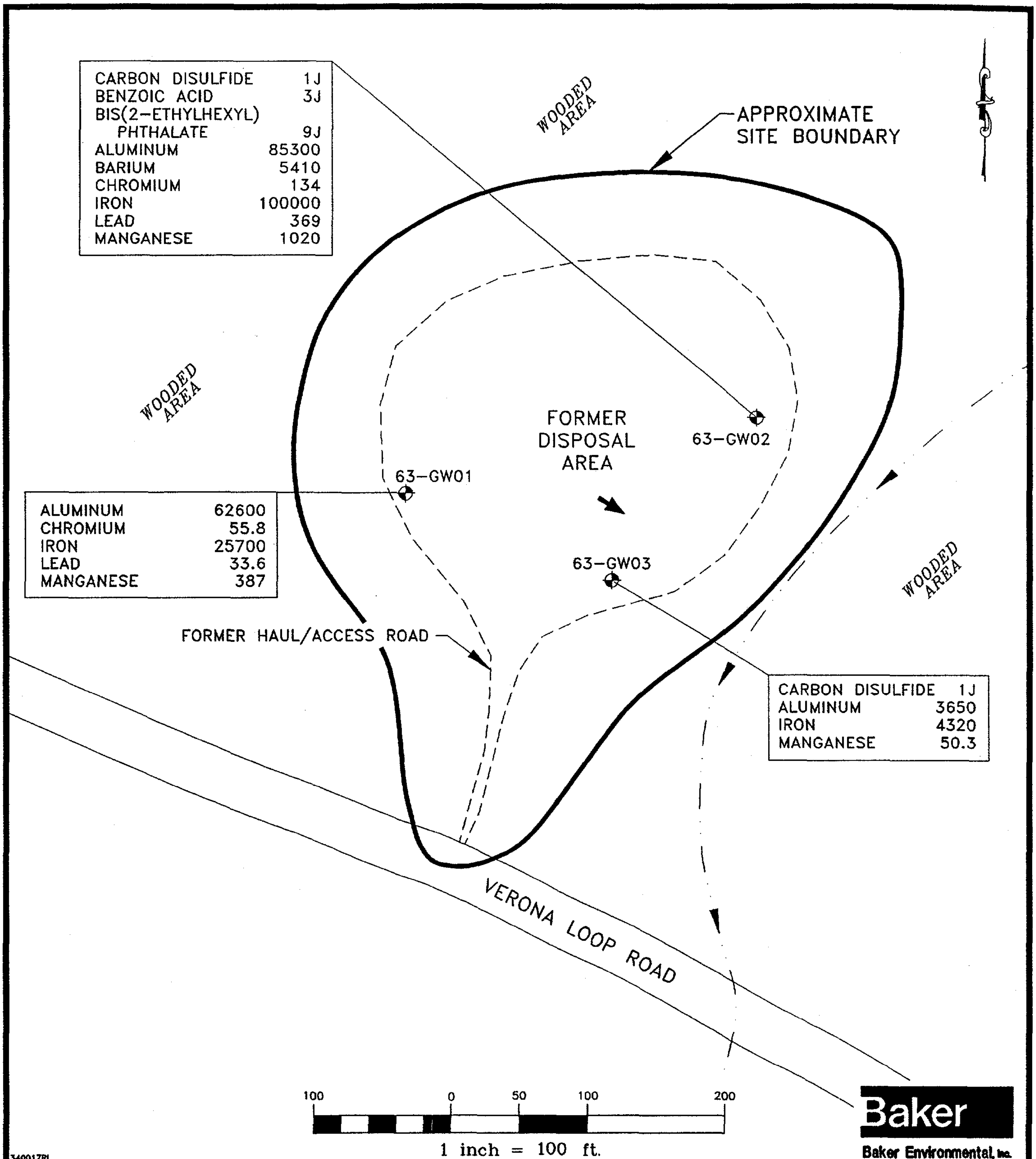
⊕ SOIL TEST BORING FOR MONITORING WELL

— · — ► APPROXIMATE LOCATION AND FLOW DIRECTION OF INTERMITTENT STREAM

ug/kg MICROGRAM PER KILOGRAM

mg/kg MILLIGRAM PER KILOGRAM

FIGURE 1-8
SITE INSPECTION SOIL ANALYTICAL RESULTS
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

- SHALLOW GROUNDWATER MONITORING WELL
- APPROXIMATE GROUNDWATER FLOW DIRECTION
- APPROXIMATE LOCATION AND FLOW DIRECTION OF INTERMITTENT STREAM

NOTES:
1. ONLY INORGANICS ABOVE FEDERAL MCL'S OR STATE GROUNDWATER STANDARDS ARE INCLUDED
2. ALL RESULTS REPORTED IN ug/l

FIGURE 1-9
SITE INSPECTION GROUNDWATER ANALYTICAL RESULTS
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

2.0 SITE CHARACTERISTICS

Section 2.0 of this report presents information concerning site-specific physical characteristics. This section includes the topography, surface water hydrology and drainage features, geology, hydrogeology, and ecology of Site 63.

2.1 Topography and Surface Features

The topography at Site 63 was approximated based on surveyed ground surface elevations at boring and well locations and is presented on Figure 2-1. A topographic high occurs at Site 63 along a northeast-southwest trending axis located immediately west of a gravel access road. A "saddle" feature is apparent along this axis in the vicinity of borings 63-SB17 and 63-SB22 due to a slight elevation decrease. This figure shows that a slope exists east of the axis. This slope represents the west bank of the unnamed tributary. The grade along the western side of the axis slopes gently to the west.

Site 63 is mainly wooded, with little undergrowth. A small area containing a few dead and fallen trees was observed in the vicinity of well 63-GW02 during a site visit in February, 1995. However, new vegetation was observed in this area at the time of investigation. Bivouac and construction wastes were observed throughout the site. These wastes included meals-ready-to-eat (MRE) packaging, ammunition containers, concrete debris, wood, and steel. Small soil mounds and entrenchments were also observed throughout the site.

2.2 Surface Water Hydrology

Surface water movement appears to be limited at Site 63 by the woodlands and undergrowth. Overland flow in the eastern portion of the site would likely travel downslope to the unnamed tributary. The unnamed tributary flows to the south, eventually emptying into Mill Run. Overland flow on the western portion of the site would flow to the west until it encountered the gravel road. There, surface water would likely remain ponded until it evaporated or infiltrated into the ground due to a lack of drainage.

2.3 Soil

According to the Soil Conservation Service (SCS) Soil Survey of Camp Lejeune, Site 63 is underlain primarily by the Pits map unit (Pt). The Marvyn (MaC) loamy fine sand occupies the unnamed tributary stream valley and bounds the Pits unit on the east. The Baymeade fine sand (BmB) bounds the Pits unit on the remaining sides. Table 2-1 provides a summary of soil physical properties found at Site 63.

The Pits unit consists of areas where the soil has been excavated. This description for the site seems appropriate given the number of "foxholes" observed. The SCS Soil Survey of Onslow County refers to the primary soil underlaying the site 63 as the Udorthents. The Onslow County survey defines the Udorthents as a unit consisting of nearly level to gently sloping, graded or filled areas. This description also seems appropriate given the site history and surface and subsurface debris observed during the investigation. The Onslow County Soil Survey describes the Udorthents as having moderate infiltration and slow surface runoff.

The Baymeade fine sand is described in the MCB, Camp Lejeune Soil Survey as typically found on slopes near large drainageways and on low ridges. Most areas where this soil is encountered are wooded and are characterized by rapid infiltration and slow runoff.

The Marvyn loamy fine sand is described in the MCB, Camp Lejeune Soil Survey as generally appearing in long and narrow bands, typically on the side of slopes (6 to 15 percent grade) near drainage areas (e.g., the unnamed tributary). This soil is characterized by moderate infiltration and medium runoff.

2.4 Geology

A general stratigraphic sequence has been identified under MCB, Camp Lejeune. This sequence is presented in a U.S. Geological Survey (USGS) report prepared for MCB, Camp Lejeune (Cardinell, et al., 1993) and shown on Table 1-1. The uppermost formation under Site 63 is an undifferentiated formation. The Belgrade Formation lies below, with the River Bend Formation below that. The borings at Site 63 are relatively shallow; none of them extend through the undifferentiated formation.

Based on cross sections discussed below, the observed undifferentiated formation at Site 63 can generally be divided into two units, the upper unit and lower unit. The upper unit consists of relatively coarse-grained sediments and fine sands with lesser amounts of silt and clay. Lenses of silt and/or clay are also present within the upper unit. Predominantly silty sediments replace portions of the sand in the northwest portion of the site. The lower unit consists of relatively fine-grained silt and clay that typically have a distinct gray color. Predominantly fine-sandy sediments replace the silt and clay in the southeast portion of the site. Even though the lower unit generally contains finer-grained sediments than the upper unit, it does not appear to be a confining or semi confining unit. Water was frequently encountered in soils collected from borings penetrating the lower unit, as evidenced in the cross sections and boring logs.

Much of the surface soil at the site has been disturbed by human activity, as evidenced by mounds, foxholes, and surface debris observed throughout the site. Debris (primarily metal) was also observed in the subsurface. Figure 2-2 shows the approximated limits of observed subsurface debris.

Geologic cross-sections depicting the shallow and deep lithologies were developed based on soils collected during the RI. Boring logs are provided in Appendix A and well boring and construction logs are provided in Appendix B. Figure 2-2 shows the locations of the cross-sections traversing Site 63 and Figures 2-3A-D depict the lithologies.

Cross-section A-A' (Figure 2-3A) traverses west to east across the site. This section depicts the upper/lower sequence described above. The upper unit extends across the length of the section, with silt and clay lenses at SB12. The lower silt/clay unit is present beneath the sand unit, but has been replaced by a fine sand at 63-TW07. The occurrence of groundwater along this section varies. Groundwater is first encountered in both upper and lower units. Groundwater was not encountered at SB09.

Cross-section B-B' (Figure 2-3B) traverses west to east across the site. This section generally depicts the upper/lower unit sequence. However, much of the upper sand unit has been replaced by silty sediments along the western portion of the section (from SB21 to SB10). The lower unit was observed in both end borings and has been projected across the length of the section. The elevation of this projected contact is consistent with observations in other borings from other sections. Groundwater generally occurs within the sandy or silty sediments. However, groundwater was first encountered in the lower unit at SB07 and just above the projected contact at SB10.

Cross-section C-C' (Figure 2-3C) traverses north to south across the site. In this section, much of the upper unit has been replaced by silty sediments (from SB14 to SB17 and SB18). The lower silt/clay unit was observed only in borings 63-TW04 and SB18 and has been projected across the width of the section. The elevation of this projected contact is consistent with observations in other borings from other sections. Groundwater occurs within the sandy or silty sediments. Groundwater was not encountered in boring SB18.

Cross-section D-D' (Figure 2-3D) traverses north to south across the site. In this section, the upper unit is present across most of the section, but has been replaced by silty sediments at SB26 and SB27. The lower unit is also present, but has been replaced by a fine sand at 63-TW06. A clay layer was observed in 63-TW06 at an elevation of approximately 25 feet above mean sea level (MSL). This layer was not observed in any other boring because of the relatively shallow boring depths. The extent and contact of this clay layer are based on geologic judgement. The occurrence of groundwater along this section varies. Groundwater is first encountered in both sand and silt/clay units. Groundwater was not encountered in boring SB26.

2.5 <u>Hydrogeology</u>

There are several aquifers and intervening confining units underlying MCB, Camp Lejeune. According to the USGS report, the surficial aquifer occurs within the sediments of the undifferentiated formation. The Castle Hayne confining unit occurs in sediments of the undifferentiated formation and the Belgrade Formation. Below the confining unit, the upper portion of the Castle Hayne Aquifer occurs in sediments of the River Bend Formation.

Only the uppermost aquifer, the surficial aquifer, was investigated in this study. The thickness of the surficial aquifer at Site 63 was not determined, because of the relatively shallow depths of the borings. Cross sections from the USGS report indicate that the Castle Hayne confining unit is absent west of Site 63. The surficial and Castle Hayne aquifers have a combined thickness of approximately 200 feet. The surficial and Castle Hayne aquifers would be expected to be hydraulically connected in the absence of a confining unit.

Hydrogeologic conditions were evaluated by installing a network of eight temporary wells and three existing, permanent wells. Additionally, two staff gauges were installed in the unnamed tributary, east of the site.

2.5.1 Groundwater Elevation Data

Groundwater and creek elevation data for Site 63 are summarized on Table 2-2. Three rounds of groundwater level measurements were collected in November and December of 1995, and February of 1996. The shallow temporary and permanent monitoring wells are screened to intercept the water table and, on average, extend to a depth of approximately 13 feet below ground surface (bgs).

Groundwater is shallow at Site 63. Groundwater was generally encountered within 10 feet of the ground surface. Groundwater water was encountered deeper in several borings primarily west of the site. Static water elevations occurred in permanent and temporary wells within 10 feet of the ground surface. Several borings, namely SB03, SB06, SB09, TW03, SB18, SB26, and TW06, were observed to be dry or to exhibit a very low groundwater infiltration rate.

The groundwater elevation data in all wells exhibit a downward trend between November and December (Figures 2-4A-C). The decrease in elevation ranged from 0.80 to 1.61 feet, with an average decrease of 1.17 feet. The data exhibit an upward trend in all wells between December and February. The increase in elevation ranged from 0.69 to 3.56 feet, with an average increase of 1.42 feet. Well 63-TW01 showed the greatest change of 3.56 feet.

Changes in the creek level elevations seem less pronounced than in groundwater. The upstream staff gauge data mimic groundwater data trends. Between November and December the observed decrease in creek level elevation at 63-SG was 1.09 feet, 0.08 feet less than the average decrease in the wells. The observed increase between December and February at 63-SG was 0.06 feet, 1.36 feet less than the average increase in the wells. Creek level elevations at the downstream staff gauge 63-SG02 barely fluctuate between observations. This may be due to the presence of a large pool of standing water upstream of 63-SG02. This pool may supply water downstream during low-flow periods.

2.5.2 Groundwater Elevation Contour Maps

Groundwater elevation contour maps were developed from static water level data collected between November of 1995 and February of 1996. The groundwater flow patterns and gradients were similar for all three data sets. The February 1996 data is presented as a groundwater elevation contour map (Figure 2-5), and appears representative of all months observed.

Site 63 appears to be a local groundwater recharge area based on two observations. First, a groundwater elevation high corresponds with a ground surface elevation high. Second, groundwater appears to flow outward (east and west) from that high point. The shape of the contours suggests that flow may be radial from the high point.

Groundwater flow follows site topography on slightly varying gradients. Flow gradients were determined by dividing a given distance of a groundwater flow direction line into the change in groundwater elevation over that distance. On the eastern side of the site, the ground surface slopes to the southeast at approximately 0.07 feet/foot. In this same area, groundwater flows to the southeast, toward the unnamed tributary on a gradient of approximately 0.05 feet/foot. On the western side of the site, the ground surface slopes to the northwest at approximately 0.033 feet/foot, and groundwater flows to the northwest, on a gradient of 0.030 feet/foot.

2.5.3 Hydraulic Properties

Rising head slug tests were conducted at Site 63 at two of the three permanent monitoring wells: wells 63-GW01 and 63-GW02. A slug test could not be performed at well 63-GW03 because the water level was observed not to be at a static condition. This may be attributable to a slow recharge rate after sampling disturbances from the previous day. Falling head tests were not conducted because static water levels were within screened intervals. The slug test data were analyzed using the Bouwer-Rice method on AQTESOLV Version 2.0 software. The solution curves are presented in Appendix C and are summarized in the paragraph which follows.

The hydraulic conductivity at well 63-GW01 was calculated to be approximately 0.9 feet/day (3.2×10^{-4} cm^2/sec). The hydraulic conductivity at well 63-GW02 was calculated to be approximately 3.9 feet/day (1.4×10^{-3} cm^2/sec). According to the SI report (Baker, 1994), well 63-GW01 was screened in clay and sand sediments. Well 63-GW02 was screened in medium-grained sediments. The higher conductivity at 63-GW02 may be attributable to the relatively coarser-grained sediments within the screened interval at this well.

The conductivity values are an order of magnitude lower than a value presented in the USGS report (Cardinell et al., 1993). This difference has been observed at other sites at Camp Lejeune as well. The average hydraulic conductivity at Site 63, based on RI slug tests is 2.9 feet/day, compared to 50 feet/day presented in the USGS report. USGS provided an estimated hydraulic conductivity value of 50 feet/day based on a general composition of fine sand, mixed with some silt and clay. The USGS value was not based on field measurements. The surficial aquifer may contain more fine-grained sediments than accounted for by USGS estimate assumptions.

2.5.4 Groundwater Flow Velocities

Groundwater flow velocities can be estimated using a variation of Darcy's equation:

$$V = Ki/n_e$$

where:

V = groundwater velocity (feet/day)
K = Hydraulic conductivity ($feet^2$/day)
i = horizontal gradient (feet/foot)
n_e = effective porosity

Velocity calculations are presented in Appendix D. Hydraulic conductivity values were determined from slug tests conducted at wells 63-GW01, and 63-GW02. Surficial aquifer hydraulic conductivity values were 0.9 feet/day at 63-GW01 and 3.9 feet/day at 63-GW02. Flow gradient values were determined by using groundwater contour spacing (Section 2.5.3). An effective porosity value of 30 percent was used (estimated from Fetter, 1988) based on the fine sands underlying the site.

The calculated groundwater flow velocities differed by an order of magnitude on the east and west sides of the site. The velocity was calculated to be 0.73 feet/day on the eastern side of the site, and 0.08 feet/day on the western side of the site. Since velocity (V) is directly proportional to hydraulic conductivity (K) and the gradient (i), the difference in velocity is attributable to the relatively higher conductivity and steeper gradient at well 63-GW02.

2.5.5 General Groundwater Flow Patterns

Groundwater flow under the site appears divergent (perhaps radial), with flow to the west and to the east. A groundwater table high corresponds with a topographic high. Groundwater east of the divide appears to be flowing towards the unnamed tributary at a velocity of approximately 0.73 feet/day. Groundwater appears to discharge to the unnamed tributary. The direction of groundwater flow and the relative elevations of the groundwater and the creek support this conclusion. Groundwater west of the divide appears to be flowing ultimately to Mill Run at a velocity of approximately 0.08 feet/day. This conclusion is based on the location of the Mill Run stream valley with respect to the observed groundwater flow direction.

The varying groundwater flow velocities can be attributed to the variant hydraulic conductivity. The hydraulic conductivity measured at 63-GW01 was 0.9 feet/day versus 3.9 feet/day at 63-GW02. Such variations can be expected in a heterogeneous aquifer. The surficial aquifer at Site 63 appears to be heterogeneous in composition. The four cross sections (Figures 2-3A through D) illustrate the changing composition both horizontally and vertically.

2.6 Identification of Water Supply Wells

Two documents were reviewed to determine if base water supply wells exist within a one-mile radius of Site 63. These reports included, Wellhead Management Program Engineering Study (Geophex, Ltd., 1991) and Preliminary Draft Report Wellhead Monitoring Study (Greenhorne & O'Mara, 1992).

Site 63 is located in a fairly remote area, away from the development associated with the Air Station. No base water supply wells were found to be within a one-mile radius of Site 63.

2.7 Site-Specific Ecology

No habitat evaluation was conducted at Site 63; however, site photographs, national wetland inventory (NWI) maps, and endangered species information were reviewed. Based upon this data review, a general overview of the habitat at Site 63 was developed.

Site 63 and surrounding areas are dominated by a mixed forest composed of loblolly pine and deciduous trees. A swamp is present along the unnamed tributary adjacent to Site 63. The topography at Site 63 is primarily flat with scattered mounds, which are often covered by soil and a blanket of pine needles.

The following trees were either identified from site photographs or would be expected to occur in the loblolly/ hardwood forest at Site 63:

- Loblolly Pine - Pinus taeda
- Sweetgum - Liquidambar styraciflua
- Southern Red Oak - Quercus falcata
- Water Oak - Quercus nigra
- White Oak - Quercus alba
- Tulip Poplar - Liriodendron tulipifera

The vegetation on the floor of this forest appears to be sparse. Often, the in loblolly/hardwood forests at Camp Lejeune seedling trees and Japanese honeysuckle (Lonicera japonica) are the primary plants growing on the forest floor. An understory layer is present in the loblolly/hardwood forest. In addition to saplings of the canopy trees, the understory contains both shrubs and vines. Shrub and vine species expected to occur in this mixed hardwood forest include the following:

- Juniper - Juniperus virginianus
- Sweet Myrtle - Myrica cerifera
- Flowering Dogwood - Cornus florida

- Sweet Bay - Magnolia virginiana
- Greenbriar - Smilax rotundifolia
- Jasmine - Gelsemium sempervirens

In the topographic lows along the unnamed tributary, tree species from the forest occur such as red maple (Acer rubrum), a tree found in wooded wetlands. Other trees may be present as well.

The understory in this area may include the following species:

- Sweet Bay - Magnolia virginiana
- Groundseltree - Baccharis halimifolia
- Redbay - Persea borbonia
- Sweet Myrtle - Myrica cerifera

These wetland shrubs are commonly found in Camp Lejeune swamps. The floor of the swamp supports wetland vegetation including switch cane (Arundinaria tecta).

The following birds would be expected to inhabit the mixed forest at Site 63:

- Carolina Wren - Thryrothorus ludovicianus
- Carolina Chickadee - Parus carolinensis
- Blue-gray Gnatcatcher - Polioptila caerulea
- Mourning Dove - Zenaida macroura
- Robin - Turdus migratorius
- Cardinal - Richmondena cardinalis
- Blue Jay - Cyanocitta cristata
- Grackle - Quiscalus quiscula

In addition, raccoon (Procyon lotor), whitetail deer (Odocoileus virginianus), and gray squirrels (Sciurus carolinensis) are expected to occur at Site 63. Anoles (Anolis carolinensis) also are found in the mixed forest.

2.7.1 Water Body Description

The study stream sampled at Site 63 is an unnamed, intermittent, freshwater tributary to Mill Run. Therefore, the study stream is classified by the NC DEHNR as "C" (NC DEHNR, 1993). The "C" classifies the water bodies as fresh water, which allows for aquatic life propagation and survival, fishing, wildlife, secondary recreation, and agriculture (NC DEHNR, 1993). The stream is shallow and narrow with clear water.

2.7.2 Sensitive Environments

This section describes the sensitive environments that were evaluated at Site 63. These include wetlands, threatened and endangered species, and other potentially sensitive environments.

2.7.2.1 Wetlands

The NC DEHNR's Division of Environmental Management (DEM) has developed guidance pertaining to activities that may impact wetlands (NC DEHNR, 1992). In addition, certain activities affecting wetlands also are regulated by the U.S. Corps of Engineers. The U.S. Fish and Wildlife Service has prepared NWI maps for the Camp Lejeune, North Carolina area by stereoscopic analysis of high altitude aerial photographs (USDI, 1982).

The study stream is an unnamed tributary to Mill Run. This tributary is an intermittent tributary. The unnamed tributary is not located in a classified wetland. However, Mill Run is classified by NWI as "PFO1C"(Palustrine, broad-leaved deciduous, forested, seasonally flooded). Information from the NWI maps was transferred to a site-specific biohabitat map (Figure 2-6).

2.7.2.2 Other Sensitive Environments

In addition to wetlands and protected species, other sensitive environments, including those listed in 40 CFR Part 300, were evaluated during Hazard Ranking System evaluations. The study stream is located in a sensitive area known as the Mill Run Swamp. Mill Run Swamp is a coastal plain, small stream swamp (Blackwater subtype). The sensitive area also includes a mesic mixed hardwood forest (a coastal plain subtype). This sensitive area is a moderate quality swamp community and low quality hardwood forest heavily impacted by training activities. Portions of the floodplain are of moderately-high quality. However, the flood plains and stream channels in this area have been impacted by excavations in and erosion from the adjacent slopes (LeBlond et.al., 1994).

Another sensitive area (the Verona Loop Road Flatwoods) is located approximately 6,000 feet to the southeast of Site 63. Conditions at Site 63 are not expected to impact this sensitive area because of the distance between them. Both sensitive areas are located on Figure 2-7.

2.7.2.3 Threatened and Endangered Species

Certain species have been granted protection by the U.S. Fish and Wildlife Service under the Federal Endangered Species Act (16 U.S.C. 1531-1543), and/or by the North Carolina Wildlife Resources Commission, under the North Carolina Endangered Species Act (G.S. 113-331 to 113-337). The protected species fall into one of the following status classifications: federal or state endangered, threatened, or candidate species; state special concern; state significantly rare; or state watch lists. While only the federal or state threatened or endangered and state special concern species are protected from certain actions, the other classified species have the potential for protection in the future.

Surveys have been conducted to identify threatened or endangered species at Camp Lejeune and several programs are underway to manage and protect them. Table 1-4 lists protected species present at the base and their protected classifications. Five rare species are extensively monitored and researched by the Camp Lejeune Fish and Wildlife Division (LeBlond et al., 1994): American alligator (Alligator mississippiensis), American loggerhead turtle (Caretta caretta), green turtle (Chelonia mydas), red-cockaded woodpecker (Picoides borealis), and the black bear (Ursus americanus).

The American alligator is considered threatened in the northernmost part of its range, which includes North Carolina. The alligator is found in freshwater, estuarine, and saltwater wetlands in Camp Lejeune. Base wetlands are maintained and protected for the alligator. Signs have been erected where alligators are known to live. Annual surveys of Wallace, Southwest, French, Duck, Mill, and Stone Creeks have been conducted since 1977 to identify alligators and their habitats on base.

Two protected sea turtles species, the Atlantic loggerhead and Atlantic green turtle, nest on Onslow Beach at Camp Lejeune and are both classified as threatened species. The green turtle was found nesting in 1980; the sighting was the first time the species was observed nesting north of Georgia. The turtle returned to nest in 1985. Turtle nests on the beach are surveyed and protected, turtles are tagged, and annual turtle status reports are issued.

The red-cockaded woodpecker is classified as state endangered. This species requires a specific habitat in mature, living longleaf or loblolly pine trees. The birds live in family groups and young are raised cooperatively. At Camp Lejeune, 2,512 acres of habitat have been identified and marked for protection. Research on the bird at Camp Lejeune began in 1985 and information has been collected to determine home ranges, population size and composition, reproductive success, and habitat use. An annual roost survey is conducted and 36 colonies of birds have been located.

Two rare bird species, Bachman's sparrow (Aimophila aestivalis) and Cooper's hawk (Accipiter cooperii) may inhabit Site 63. Bachman's sparrow is classified as candidate endangered species by the federal government and as a species of special concern by the state. Cooper's hawk is classified as species of special concern by the state only during the nesting season. Bachman's sparrows inhabit open pine woods with open understories and thick ground cover of herbs. Cooper's hawks prefer mature forests, especially broadleaf forests.

A natural heritage resources survey was conducted at Camp Lejeune (LeBlond et al., 1994) to identify threatened or endangered plants and areas of significant natural interest. The results of this survey are included in Appendix J. Chapman's sedge (Carex chapmanii), which occurs in Mill Run Swamp, is a candidate (level 2) on the federal endangered species list and threatened species on the state list. Drooping bulrush (Scirpus lineatus) is also known to inhabit the sensitive area around Site 63. This plant is listed as a candidate endangered species by the state (LeBlond et.al., 1994).

2.8 References

Baker Environmental, Inc. January 1994. Site Inspection Report - Site 63, Verona Loop Dump. Final. Prepared for the Department of the Navy, Naval Facilities Engineering Command, Atlantic Division, Norfolk, Virginia.

Barnhill, W.L. 1984. Soil survey of Camp Lejeune, North Carolina. USDA, Soil conservation Service.

Cardinell, A.P., Berg, S.A., and Lloyd O.B., Jr. 1993. Hydrogeologic Framework of U.S. Marine Corps Base at Camp Lejeune, North Carolina. USGS. Water-resources Investigations Report 93-4049.

Fetter, C.W. 1986. Applied Hydrogeology. Charles E. Merrill Publishing co., Columbus, Ohio.

Geophex, Ltd. 1992. Wellhead Management Program Engineering Study 91-36. Prepared for Marine Corps Base, Camp Lejeune, North Carolina. January 22, 1992.

Greenhorne & O'Mara. 1992. Preliminary Draft Report Wellhead Monitoring Study. Prepared for the Department of the Navy, Civil Branch. December, 1992.

Harned, D.A., Lloyd, O.B., Jr., and Treece, M.W., Jr. 1989. Assessment of Hydrologic and Hydrogeologic Data at Camp Lejeune Marine Corps Base, North Carolina. USGS. Water-Resources Investigations Report 90-4096.

LeBlond, Richard. 1991. Critical species List - Camp Lejeune Endangered Species and Special-Interest Communities Survey. Principal Investigator.

LeBlond, Richard, Fussel, John, and Alvin Braswell. 1994. "Inventory of the Rare Species, Natural Communities, and Critical Areas of the Camp Lejeune Marine Corps Base, North Carolina." For the North Carolina Natural Heritage Program, Division of Parks and Recreation, Department of Environment, Health, and Natural Resources. February 1994.

NC DEHNR. 1993. North Carolina Department of Environment, Health, and Natural Resources. Classifications and Water Quality Standards Applicable to Surface Waters of North Carolina. Administrative Code 15A NCAC 2 B. .0200. Division of Environmental Management. February 1993.

NC DEHNR. 1992. North Carolina Department of Environment, Health, and Natural Resources. Interim Guidance for Wetlands Protection. Division of Environment, Water Quality. May 1992.

USDA Soil Conservation Service. Soil Survey of Onslow County, North Carolina. 1992.

USDI. 1982. United States Department of the Interior. National Wetland Inventory Map, Camp Lejeune, N.C. Fish and Wildlife Service. March 1982.

USMC, MCB Camp Lejeune. 1987. Multiple-Use Natural Resources Management Plan. Fish and Wildlife Division, Environmental Management Department, Marine Corps Base, Camp Lejeune, North Carolina.

SECTION 2.0 TABLES

TABLE 2-1

SUMMARY OF SOIL PHYSICAL PROPERTIES
SITE 63 VERONA LOOP DUMP
REMEDIAL INVESTIGATION CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Soil Name	Soil Symbol	USCS Classification	Depth (inches)	Moist Bulk Density (g/cc)	Permeability (cm/s)	Soil Reaction (pH)	Shrink-Swell Potential	Organic Matter (percent)
Baymeade-Fine Sand	BmB	SM, SP-SM	0 - 30	1.60 - 1.75	4.2×10^{-3} - 1.37×10^{-2}	4.5 - 6.5	Low	0.5 - 1.0
Marvyn	MaC	SM	0 - 12	--	1.37×10^{-3} - 4.2×10^{-3}	4.5 - 6.0	Low	<2.0

Source: Soil Survey: Camp Lejeune, North Carolina, U. S. Department of Agriculture - Soil Conservation Service, 1984.

Notes:

The Camp Lejeune and Onslow County Soil Surveys do not provide any physical characteristic data for the Pits/Udorthents unit. Thus, the units are not listed on this table.

ML = Loam
SM = Loamy Fine Sand
SP = Fine Sand
-- = Not Estimated
SC = Fine Sandy Loam

TABLE 2-2

SUMMARY OF WATER LEVEL MEASUREMENTS
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well ID	Reference Elevation[1]	SWL Nov. 16, 1995	SWL Dec. 16, 1995	SWL Feb. 24, 1996	SWE Nov. 16, 1995	SWE Dec. 16, 1995	SWE Feb. 24, 1996
63-GW01	51.28	9.16	10.77	9.88	42.12	40.51	41.40
63-GW02	48.42	9.56	10.37	9.70	38.86	38.05	38.72
63-GW03	47.54	NA	9.26	7.71	NA	38.28	39.83
63-TW01	40.62	9.30	10.10	6.54	31.32	30.52	34.08
63-TW02	46.38	10.88	12.20	10.42	35.50	34.18	35.96
63-TW03	45.77	10.63	11.91	10.12	35.14	33.86	35.65
63-TW04	50.92	9.00	10.10	9.34	41.92	40.82	41.58
63-TW05	50.80	7.13	7.95	7.26	43.67	42.85	43.54
63-TW06[2]	33.07	NA	NA	NA	NA	NA	NA
63-TW07	41.53	8.99	10.15	8.78	32.54	31.38	32.75
63-TW08	38.85	5.88	7.48	6.20	32.97	31.37	32.65
63-SG01[3]	29.84	2.81	1.72	1.78	29.31	28.22	28.28
63-SG02[3]	24.73	1.16	1.20	1.18	22.55	22.59	22.57

Notes:

(1) Top of PVC well casing (in feet above mean sea level [MSL])
(2) PVC casing is loose - unreliable data
(3) Staff gauge
SWL = Static water level taken from top of PVC well casing
SWE = Static water elevation (in feet above MSL)
NA = Data not available

SECTION 2.0 FIGURES

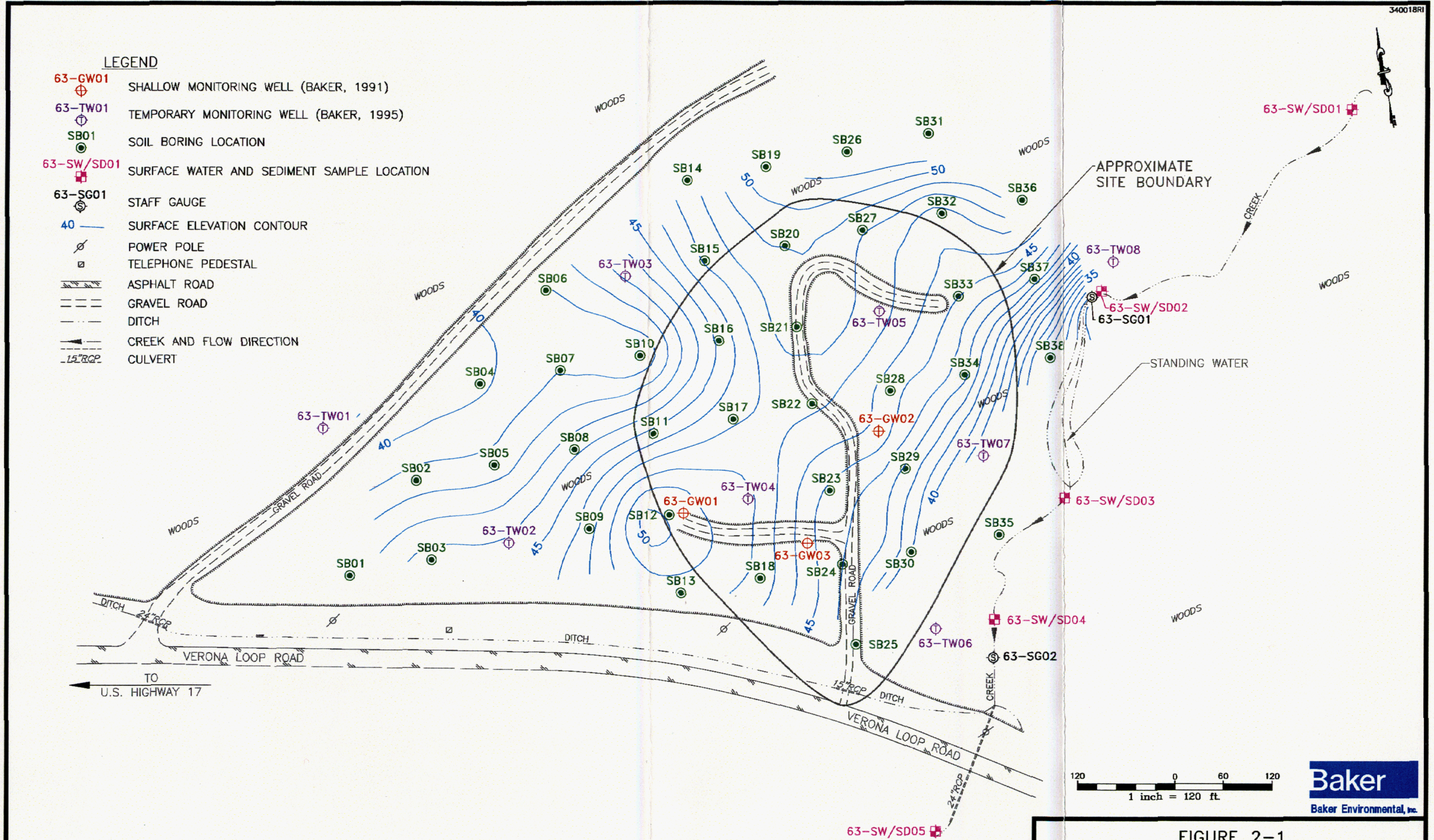


FIGURE 2-1
SURFACE CONTOURS
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

SOURCE: LANTDIV, 1992
SURVEY: W.K. DICKSON & ASSOC., 1995

01708N10Y

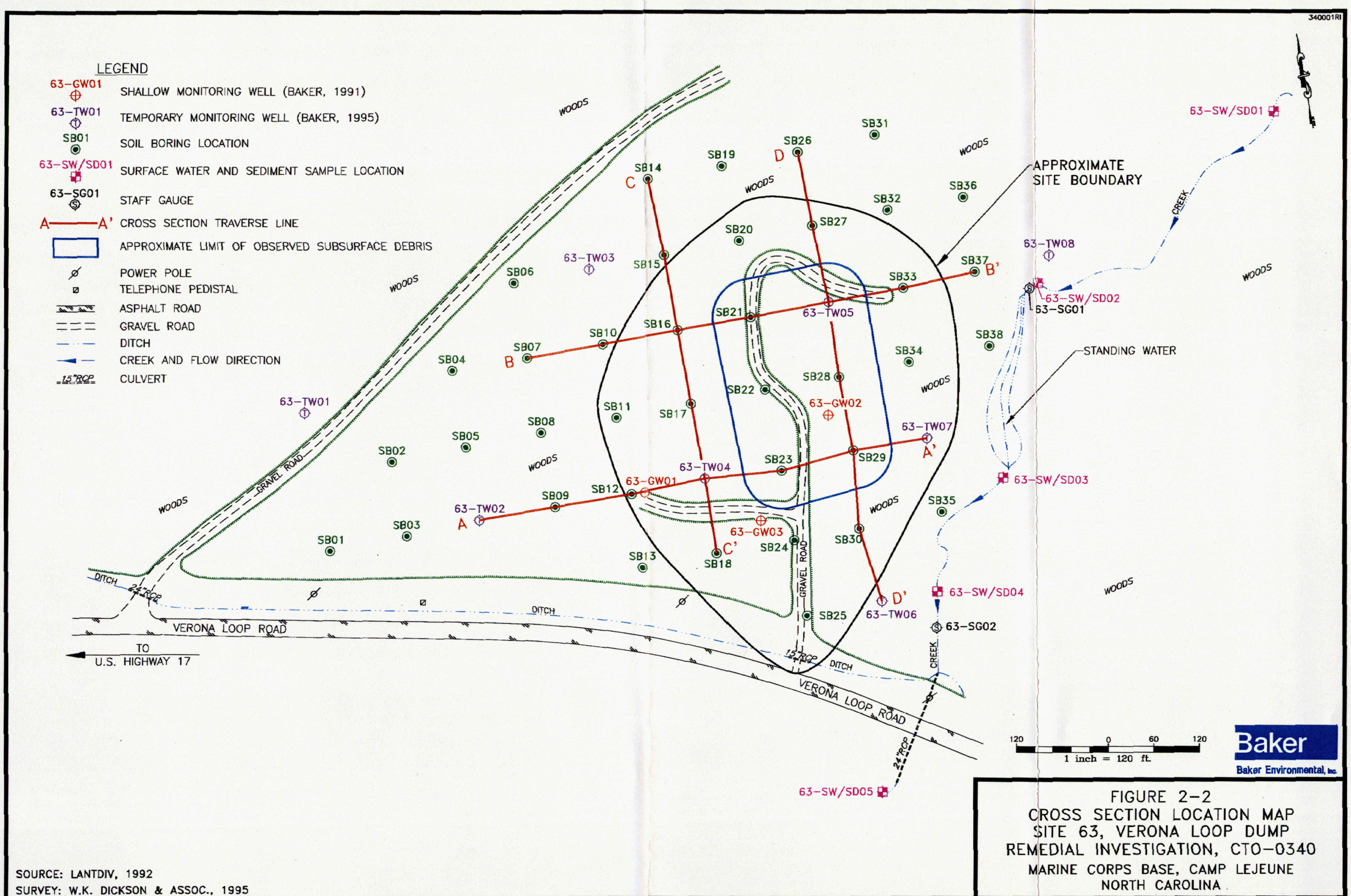
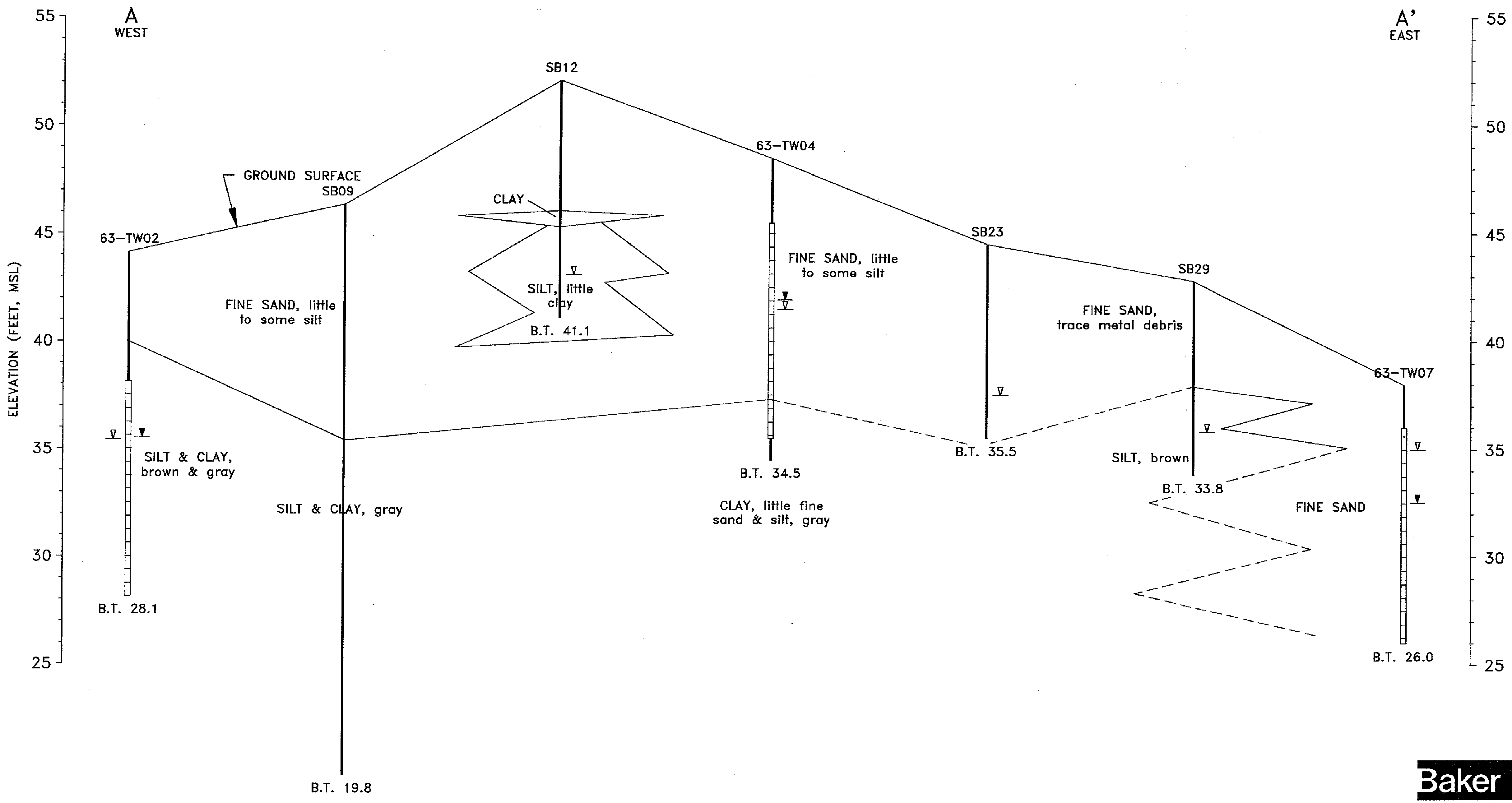


FIGURE 2-2
CROSS SECTION LOCATION MAP
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01708N11Y

340002RI



Baker
Baker Environmental, Inc.

LEGEND

▼	GROUNDWATER ELEVATION (11/16/95)
▽	GROUNDWATER ENCOUNTERED DURING DRILLING
B.T. 28.1'	BORING TERMINATED, ELEVATION MSL
▯	WELL SCREEN INTERVAL
———	ESTIMATED
— — —	PROJECTED

50 0 25 50 100
Horizontal Scale: 1 inch = 50 ft.

5 0 2.5 5 10
Vertical Scale: 1 inch = 5 ft.

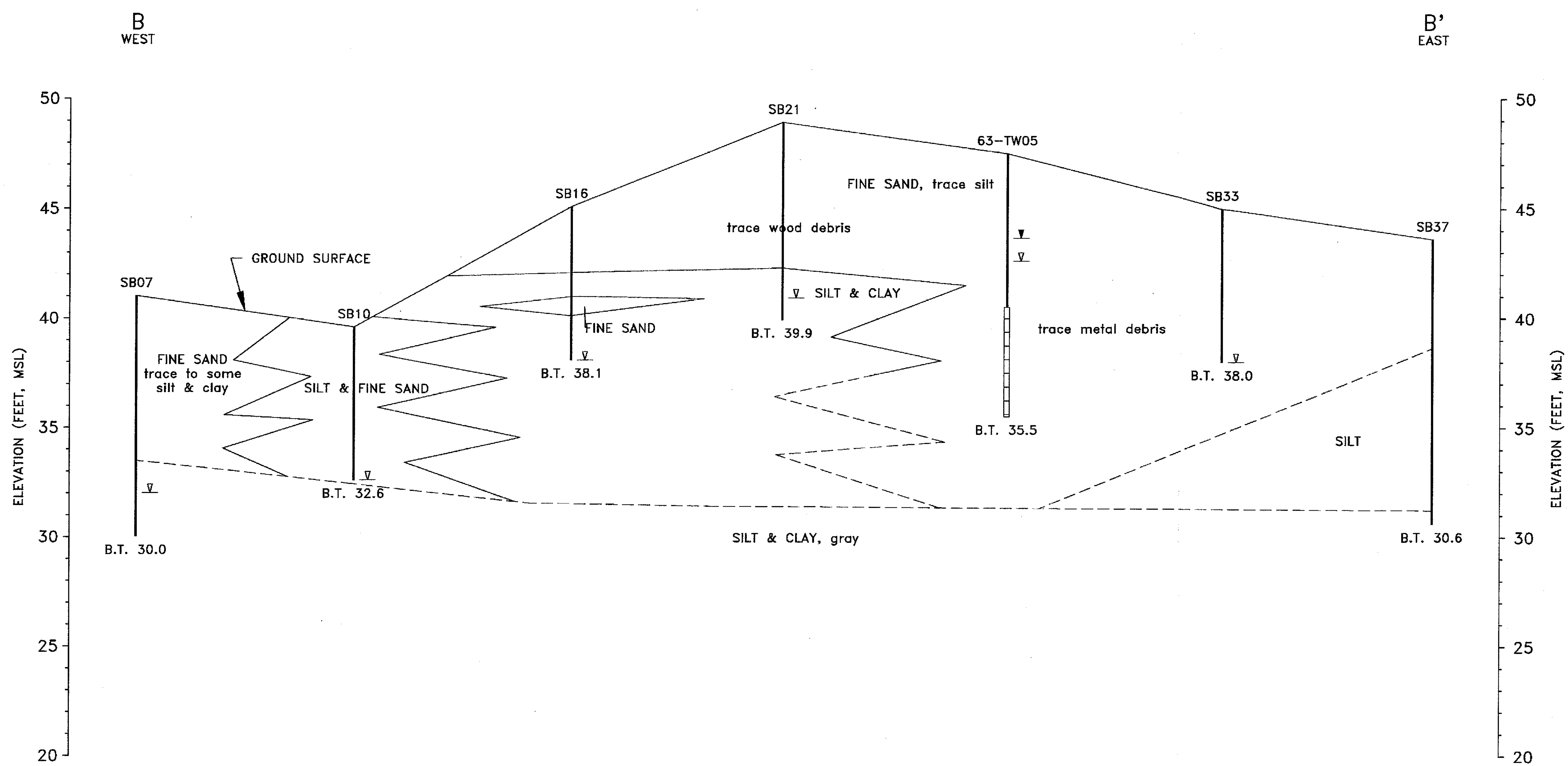
THE SOIL BORING INFORMATION IS CONSIDERED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT THE RESPECTIVE BORING LOCATIONS. SUBSURFACE CONDITIONS INTERPOLATED BETWEEN BORINGS ARE ESTIMATED BASED ON ACCEPTED SOIL ENGINEERING PRINCIPLES AND GEOLOGIC JUDGEMENT.

FIGURE 2-3A
HYDROGEOLOGIC CROSS-SECTION A-A'
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01708N122

340003RI



Baker
Baker Environmental, Inc.

LEGEND

- GROUNDWATER ELEVATION (11-16-95)
- GROUNDWATER ENCOUNTERED DURING DRILLING
- B.T. 32.6' BORING TERMINATED, ELEVATION MSL
- WELL SCREEN INTERVAL
- ESTIMATED
- PROJECTED

50 0 25 50 100
Horizontal Scale: 1 inch = 50 ft.

5 0 2.5 5 10
Vertical Scale: 1 inch = 5 ft.

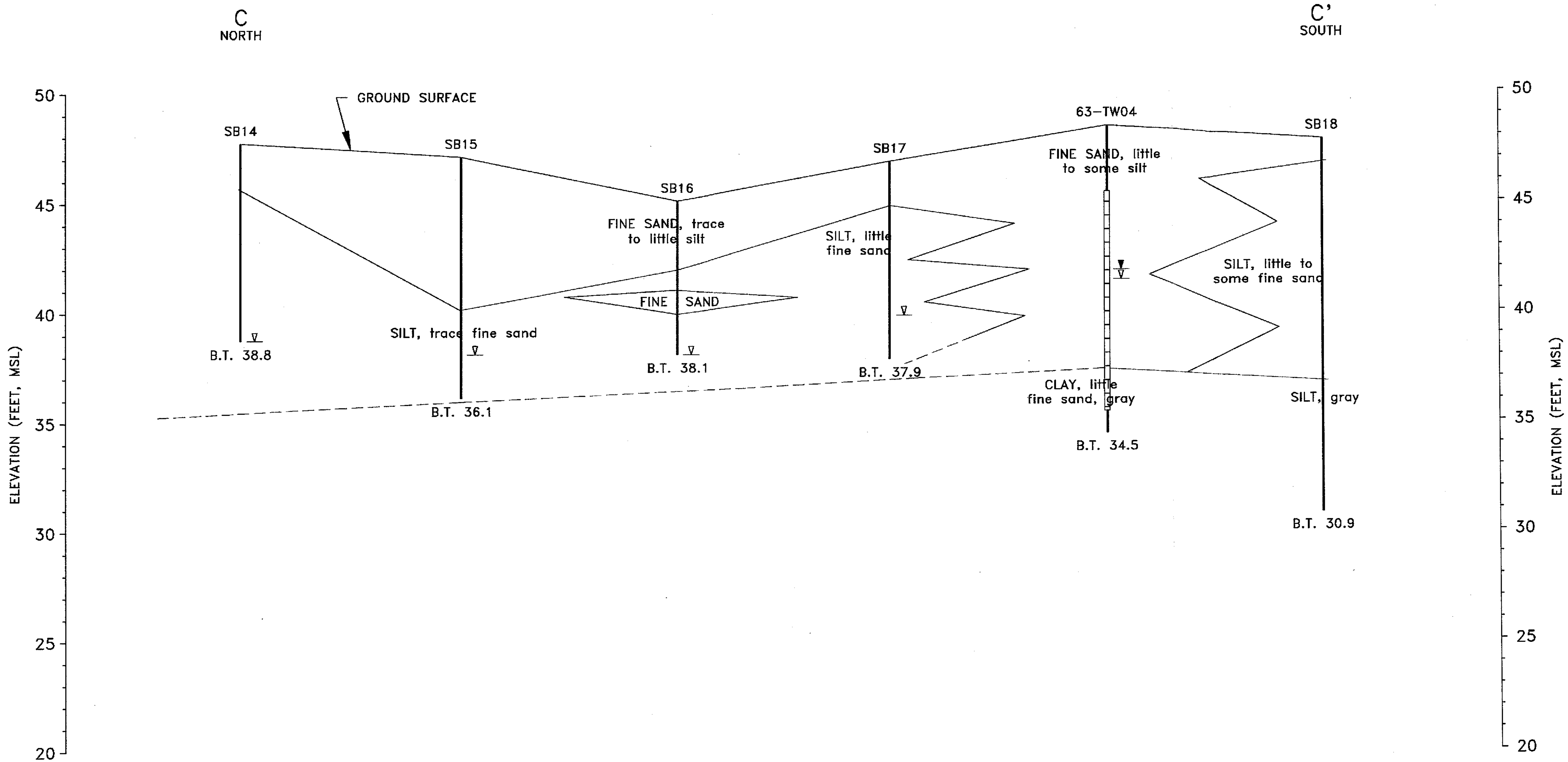
THE SOIL BORING INFORMATION IS CONSIDERED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT THE RESPECTIVE BORING LOCATIONS. SUBSURFACE CONDITIONS INTERPOLATED BETWEEN BORINGS ARE ESTIMATED BASED ON ACCEPTED SOIL ENGINEERING PRINCIPLES AND GEOLOGIC JUDGEMENT.

FIGURE 2-3B
HYDROGEOLOGIC CROSS-SECTION B-B'
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01708N132

340004RI



Baker
Baker Environmental, Inc.

LEGEND

▼	GROUNDWATER ELEVATION (11/16/95)
▽	GROUNDWATER ENCOUNTERED DURING DRILLING
B.T. 38.8'	BORING TERMINATED, ELEVATION MSL
	WELL SCREEN INTERVAL
———	ESTIMATED
— — —	PROJECTED

50 0 25 50 100
Horizontal Scale: 1 inch = 50 ft.

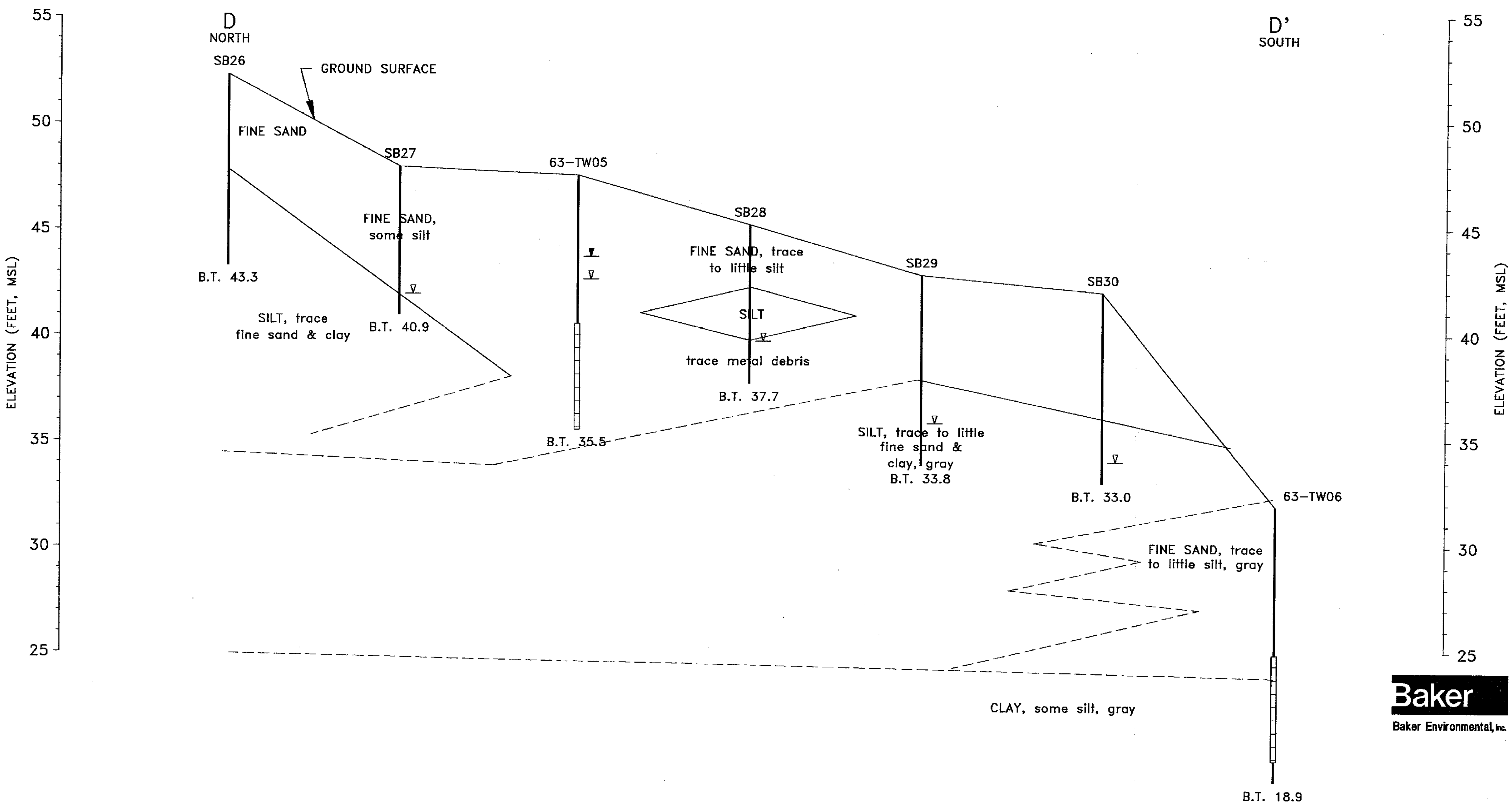
5 0 2.5 5 10
Vertical Scale: 1 inch = 5 ft.

THE SOIL BORING INFORMATION IS CONSIDERED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT THE RESPECTIVE BORING LOCATIONS. SUBSURFACE CONDITIONS INTERPOLATED BETWEEN BORINGS ARE ESTIMATED BASED ON ACCEPTED SOIL ENGINEERING PRINCIPLES AND GEOLOGIC JUDGEMENT.

FIGURE 2-3C
HYDROGEOLOGIC CROSS-SECTION C-C'
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01708N14Z



Baker
Baker Environmental, Inc.

LEGEND

▼	GROUNDWATER ELEVATION (11/16/95)
▽	GROUNDWATER ENCOUNTERED DURING DRILLING
B.T. 43.3'	BORING TERMINATED, ELEVATION MSL
	WELL SCREEN INTERVAL
———	ESTIMATED
— — —	PROJECTED

60 0 30 60 120
Horizontal Scale: 1 inch = 60 ft.

5 0 2.5 5 10
Vertical Scale: 1 inch = 5 ft.

THE SOIL BORING INFORMATION IS CONSIDERED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT THE RESPECTIVE BORING LOCATIONS. SUBSURFACE CONDITIONS INTERPOLATED BETWEEN BORINGS ARE ESTIMATED BASED ON ACCEPTED SOIL ENGINEERING PRINCIPLES AND GEOLOGIC JUDGEMENT.

FIGURE 2-3D
HYDROGEOLOGIC CROSS-SECTION D-D'
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01708N152

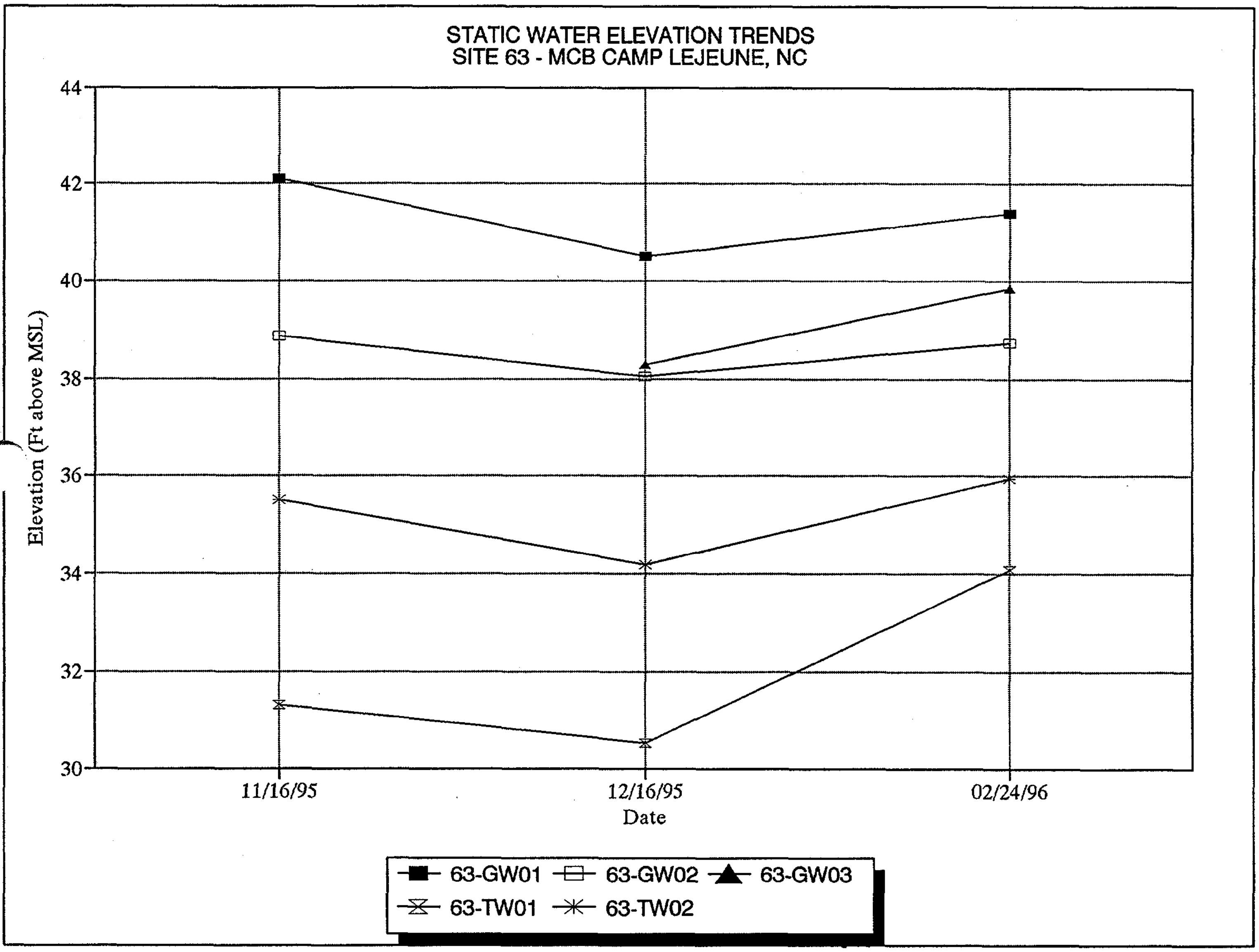


FIGURE 2-4A
STATIC WATER ELEVATION TRENDS
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

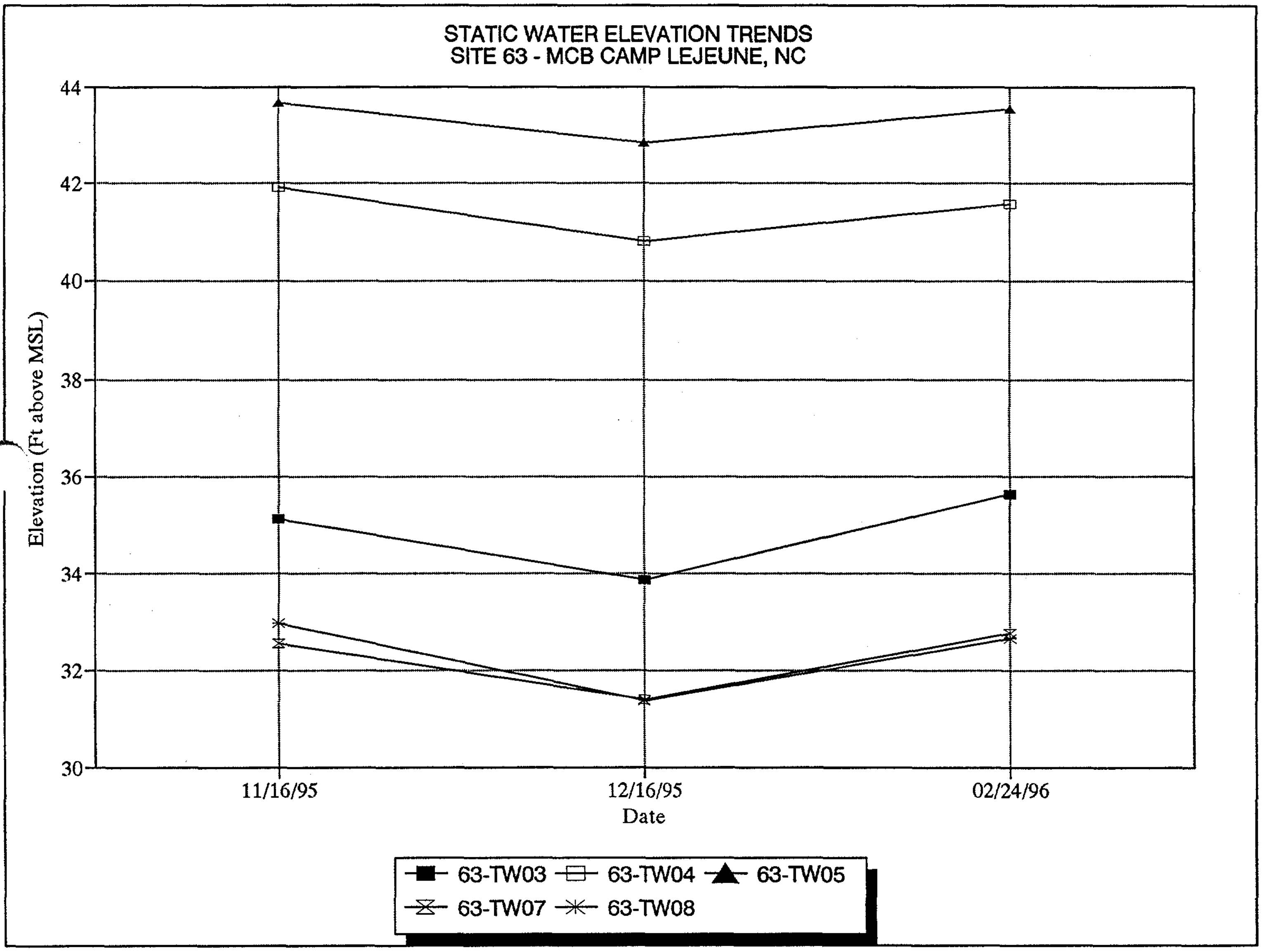


FIGURE 2-4B
STATIC WATER ELEVATION TRENDS
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

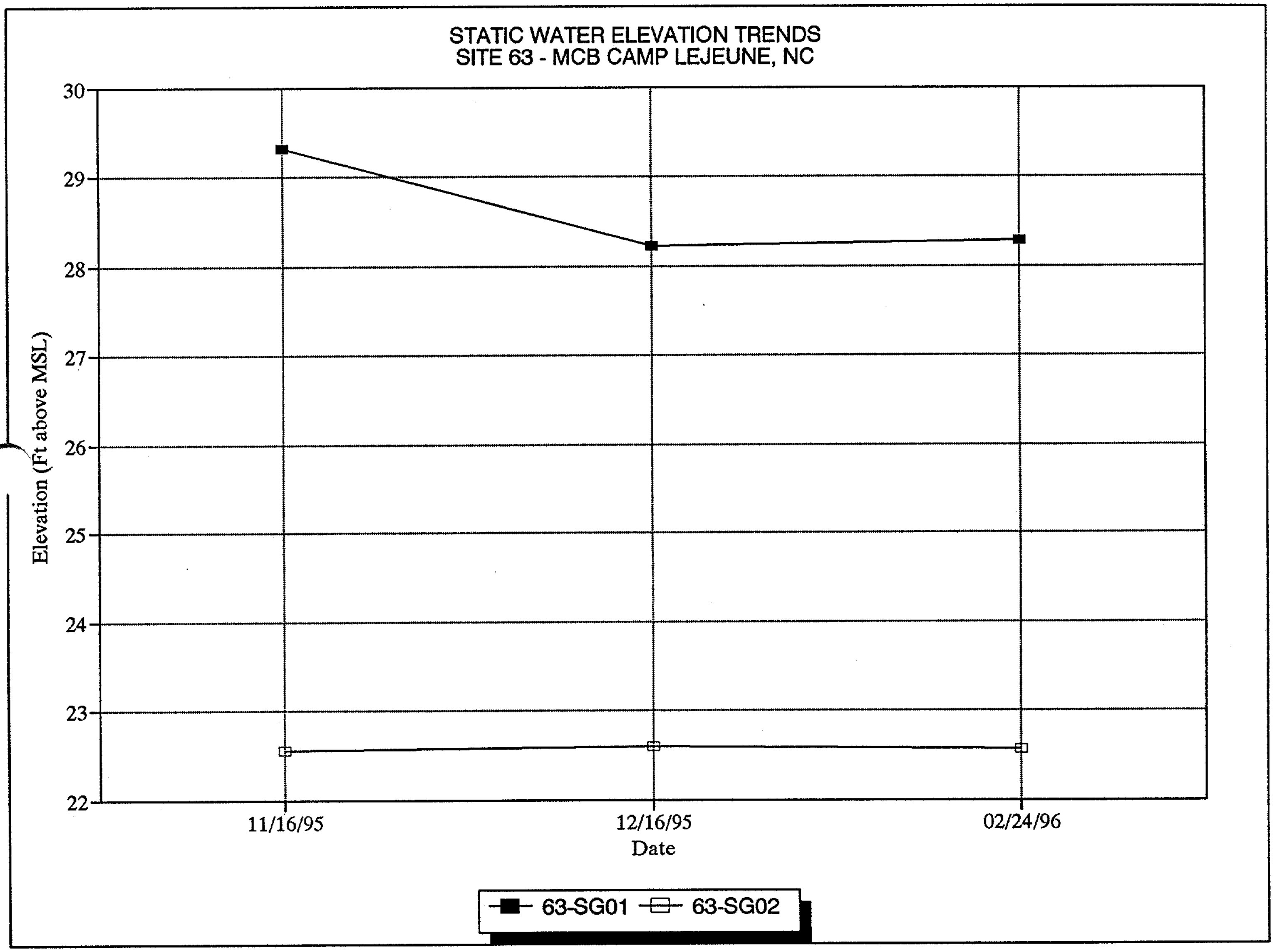


FIGURE 2-4C
STATIC WATER ELEVATION TRENDS
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

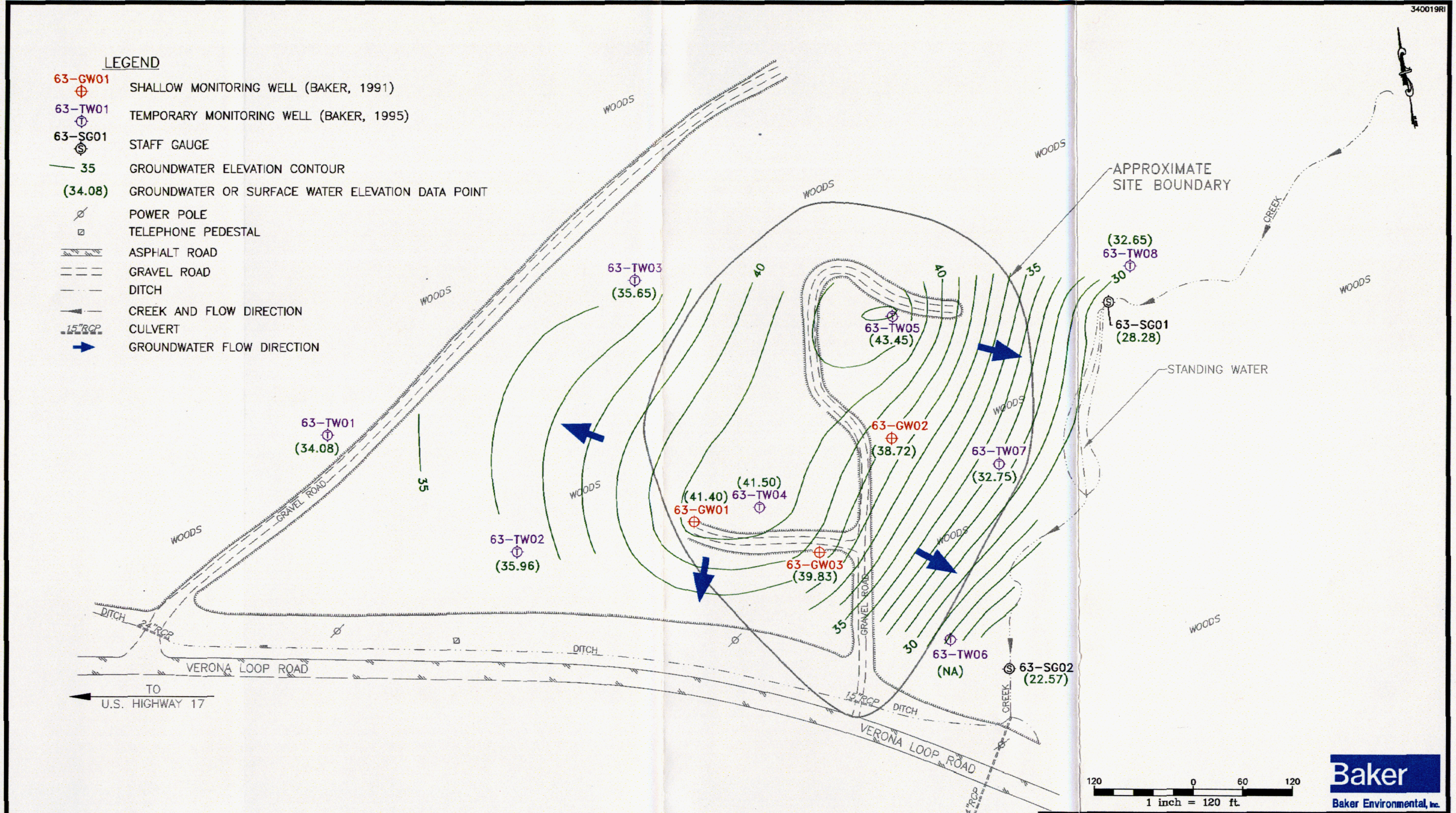


FIGURE 2-5
GROUNDWATER ELEVATION CONTOUR MAP (FEB. 1996)
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

SOURCE: LANTDIV, 1992
SURVEY: W.K. DICKSON & ASSOC., 1995

01708N16Y

FIGURE 2-6
BIOHABITAT MAP
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

SOURCE: LANTDIV, 1992
SURVEY: W.K. DICKSON & ASSOC., 1995

01708N17Y

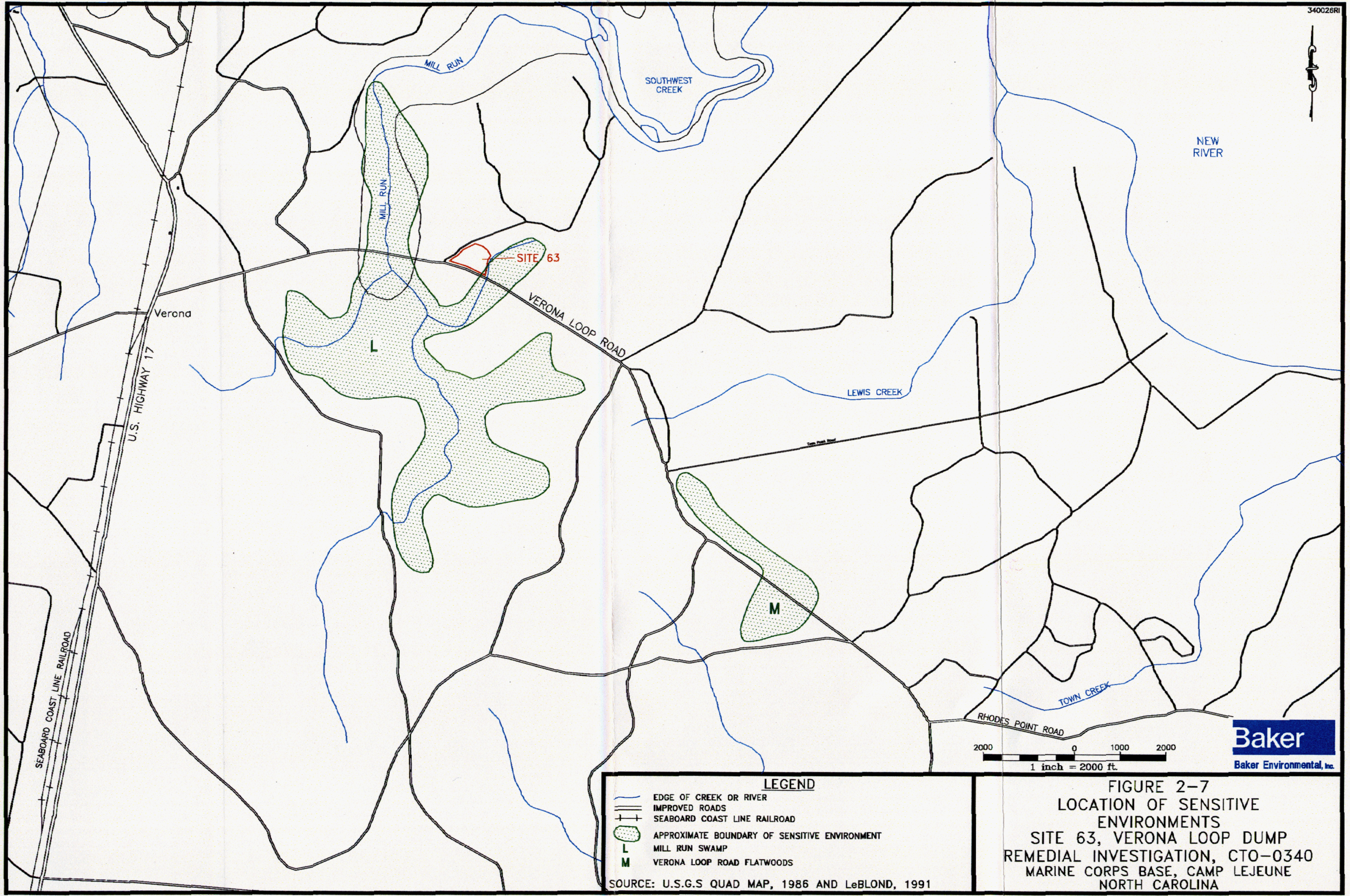


FIGURE 2-7
LOCATION OF SENSITIVE ENVIRONMENTS
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01708N18Y

3.0 STUDY AREA INVESTIGATIONS

The field investigation program at OU No. 13, Site 63, was initiated to detect and characterize potential impacts to human health and the environment resulting from past waste management activities. This section discusses the site-specific RI field investigation activities that were conducted to fulfill that objective. The RI field investigation of OU No. 13 commenced on November 2, 1995 and continued through November 16, 1995. The RI field program at Site 63 consisted of a site survey; a soil investigation, which involved direct-push sample collection; a groundwater investigation, which included temporary monitoring well installation, sampling, and aquifer testing; a surface water and sediment investigation; and a habitat evaluation. The following sections detail the various investigation activities carried out during the RI.

3.1 Site Survey

The site survey task was performed in two phases: Phase I - Initial Survey of Site Features; and Phase II - Post Investigation Survey of Monitoring Wells and Sampling Locations. Both phases of the survey task were conducted at Site 63 during November of 1995. Based upon the Initial Assessment Study (WAR, 1983) and the Site Inspection Report (Baker, 1994), surface features within and surrounding the suspected disposal portion of the study area were surveyed. The proposed soil boring and monitoring well locations identified in the Final RI/FS Project Plans for OU No. 13 (Baker, 1995), were subsequently located as part of the Phase I survey and marked with wooden stakes. Each sample location was assigned a unique identification number that corresponded to the site and media to be sampled.

Phase II of the survey task was completed at Site 63 during the week of November 13, 1995. During Phase II, both the existing monitoring wells and the newly installed temporary monitoring wells were surveyed. Supplemental or relocated soil borings completed during the investigation were also surveyed. Additionally, surface water and sediment sampling stations and staff gauges installed in the unnamed tributary were also surveyed during Phase II. Latitude, longitude, and elevation in feet above mean sea level (msl) were recorded for each surveyed point.

3.2 Soil Investigation

The soil investigation performed at Site 63 was intended to:

- Assess the nature and extent of contamination that may have resulted from previous disposal practices or site activities.
- Assess the human health, ecological, and environmental risks associated with exposure to surface and subsurface soils.
- Characterize the geologic setting of the study area.

The subsections which follow describe soil sample collection procedures, soil boring locations, and the analytical program initiated during the investigation at Site 63.

3.2.1 Soil Sampling Procedures

Sampling activities at Site 63 commenced on November 6, 1995. Soil collection was performed using a direct-push (GeoProbe™) sampling system. Borings were advanced by either a truck-mounted rig or by a hand sampler unit. The direct-push sampling system employed a stainless steel cutting shoe and collection tube. A dedicated acetate liner, inserted into the stainless steel collection tube, was used to collect and then extrude soil samples for field and laboratory analyses. All soil sampling activities conducted at Site 63 were performed in Level D personnel protection. Soil cuttings obtained during the soil investigation were collected, handled, and stored according to the procedures outlined in Section 3.7.

Two types of borings were installed during the soil investigation: exploratory test borings (i.e., borings installed for sample collection and description of subsurface units) and borings advanced for temporary monitoring well installation. Selected soil samples from each of the two types of borings were submitted for laboratory analysis (see Section 3.2.3). Soils obtained from exploratory borings were collected from the surface (i.e., ground surface to a depth of twelve inches) and at continuous two-foot intervals starting at one foot below ground surface. Continuous sample collection proceeded until the boring was terminated at the approximate depth of the water table, which varied at Site 63 from one to 13 feet below ground surface. An additional soil sample was obtained from below the water table to confirm groundwater depth and ensure that the true water table had been encountered (i.e., not a perched zone).

As previously discussed, samples were collected for soil description from the ground surface and at continuous two-foot intervals to the water table. Each soil sample was classified in the field by a geologist using the Unified Soil Classification System (USCS) in accordance with the visible-manual methods described by the American Society for Testing and Materials (ASTM, 1993). Descriptions were recorded in a field logbook and later transposed onto boring log records. Soil classification included characterization of soil type, grain size, color, moisture content, relative density, plasticity, and other pertinent information such as indications of contamination. Descriptions of site soils are provided on Test Boring Records in Appendix A and on Test Boring and Well Construction Records in Appendix B.

Surface and selected subsurface (i.e., greater than one foot below ground surface) soil samples were retained for laboratory analysis from each of the soil test borings. Both surface and subsurface samples were collected to estimate the nature and extent of potentially impacted soils and to perform the human health risk assessment; however, only the surface soils were used for the ecological risk assessment. A summary of test boring identification numbers, boring depths, sampling intervals, and laboratory analyses for soil samples is provided in Tables 3-1 and 3-2.

Where conditions warranted (i.e., when groundwater was encountered at depths greater than two feet below ground surface) a minimum of two samples were retained for laboratory analyses from each of the soil boring locations. In some cases, a third sample from the borehole was also submitted for analysis if indications of contamination (i.e., elevated photoionization detector (PID) readings or visible contamination) were noted or if the water table was encountered more than ten feet below ground surface. Each soil sample was prepared and handled according to USEPA Region IV Standard Operating Procedures (SOPs). Samples collected for volatile organic analysis were extracted with a stainless-steel spoon from different sections of the extruded soil core so that the resulting composite was representative of the entire sampling interval. Precautions were taken to avoid aerating the sample, thus minimizing volatilization. Samples retained for other analytical parameters (e.g., semivolatiles, pesticides, PCBs, and metals) were thoroughly homogenized prior to being placed in the appropriate laboratory containers.

Following sample collection, samples retained for laboratory analysis were stored on ice in a cooler. Sample preparation also included documentation of sample number, depth, location, date, time, and analytical parameters in a field logbook. Chain-of-custody documentation, provided in Appendix E, accompanied the samples to the laboratory. Information such as sample number, date, time of sampling, and sampling personnel were provided on the chain-of-custody documents. Samples were shipped by overnight courier to the laboratory.

3.2.2 Sampling Locations

Representative samples from the study area were collected and submitted for laboratory analysis of target compound list (TCL) organics (i.e., volatiles, semivolatiles, pesticides, and PCBs) and target analyte list (TAL) metals. A total of 46 test borings were sampled during the soil investigation at Site 63; 96 soil samples were collected throughout the study area as shown on Figure 3-1. The sampling distribution employed was intended to identify if contamination was present and, if so, to estimate the vertical and horizontal extent of contamination within the study area. The soil sampling program at Site 63 focused on known or suspected disposal areas. Previous investigatory data and background reports were used to locate potential sampling locations. A total of 46 test borings were advanced to assess suspected waste disposal at Site 63; eight of those borings were utilized for the installation of temporary monitoring wells (refer to Figure 3-1).

3.2.3 Analytical Program

The analytical program, initiated during the soil investigation at Site 63, focused on suspected contaminants of concern, as indicated by information regarding previous disposal practices and investigation results. Samples from each of the 46 test borings were analyzed for full TCL organics and TAL inorganics (refer to Tables 3-1 and 3-2). Two composite soil samples were also collected for analysis of engineering parameters (i.e., particle size, and Atterberg limits). The engineering samples were comprised of individual grab samples collected from soil collected between the ground surface and the water table. Samples were prepared and handled as described in the previous section. Tables 3-1 and 3-2 present a summary of requested soil analyses.

3.2.4 Quality Assurance and Quality Control

Field QA/QC samples were collected during the soil investigation. These samples were obtained to: (1) monitor that decontamination procedures were properly implemented (equipment rinsate samples); (2) evaluate field methodologies (duplicate samples); (3) establish field background conditions (field blanks): and (4) evaluate whether cross-contamination occurred during sampling and shipping (trip blanks). Data Quality Objectives (DQOs) for the QA/QC samples were implemented in accordance with DQO Level IV as defined in the Environmental Compliance Branch SOPs and Quality Assurance Manual, USEPA Region IV (USEPA, 1991). This DQO level is equivalent to the Naval Facilities Engineering Service Center (NFESC) DQO Level D, as specified in the "Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation Restoration Programs" document (NEESA, 1988).

Four types of field QA/QC samples were collected and analyzed including duplicate samples, equipment rinsates samples, field blanks, and trip blanks. Each is defined below (USEPA, 1991):

- Duplicate Sample: Two or more samples collected simultaneously into separate containers from the same source under identical conditions.

- Equipment Blanks: Equipment field blanks (or rinsate blanks) are defined as samples which are obtained by running organic-free water over/through sample collection equipment after it has been cleaned. These samples are used to determine if decontamination procedures were adequate. A minimum of one equipment blank per sample media was collected daily; however, only every other blank was analyzed.

- Field Blanks: Organic-free water is taken to the field in sealed containers and poured into the appropriate sample containers at designated locations. This is done to determine if contaminants present in the area may have an affect on the sample integrity.

- Trip Blanks: Trip blanks are prepared prior to the sampling event, placed in the actual sample container, and kept with the investigative samples throughout the sampling event. They are then packaged for shipment with the other samples and sent for analysis. At no time after their preparation are the sample containers to be opened before they return to the laboratory. Field sampling teams utilize volatile organic trip blanks to determine if samples were contaminated during storage and transportation back to the laboratory. If samples are to be shipped, trip blanks are to be provided for each shipment but not necessarily for each cooler (i.e., trip blanks in coolers with samples for VOC analyses only).

Table 3-3 summarizes field QA/QC sample types, sample frequencies, the number of QA/QC samples, and parameters analyzed. Field QA/QC samples were collected at Site 63 according to the procedures outlined in the USEPA Region IV SOPs.

3.2.5 Air Monitoring and Field Screening

Several air monitoring and field screening procedures were implemented during soil investigation activities at Site 63. Ambient air monitoring for volatile contaminants was performed at each open borehole using a photo ionization detector (PID).

Soil samples were field screened for volatile organic contaminants with a PID. Measurements obtained in the field were recorded in a logbook and later transposed onto the Test Boring Records and the Well Construction Records (provided in Appendices A and B). Prior to daily monitoring, the field instruments were calibrated and documentation was recorded in a field logbook and on appropriate calibration forms.

3.3 Groundwater Investigation

The groundwater investigation performed at Site 63 was intended to:

- Assess the nature and extent of contamination that may have resulted from previous disposal practices or site activities.

- Assess human health and environmental risks associated with exposure to groundwater.

- Characterize the hydrogeologic setting of the study area.

The subsections which follow describe well installation procedures, sample collection procedures, the analytical program, and hydraulic conductivity test procedures employed during the groundwater investigation at Site 63.

3.3.1 Monitoring Well Installation

In addition to the three existing permanent wells at Site 63, eight temporary wells were used to further assess groundwater conditions. The eight shallow temporary monitoring wells (i.e., wells installed to evaluate the upper most portion of the surficial aquifer and then be removed after sample acquisition) were installed throughout Site 63. The newly installed temporary shallow monitoring wells were situated spatially to intercept potentially impacted groundwater from the suspected disposal area, and to characterize the nature and horizontal extent of possible contamination. The network of newly-installed temporary and existing monitoring wells was also used to study groundwater flow patterns within the upper portion of the surficial aquifer. Placement of the temporary monitoring wells was based on review of previous investigations and analytical data generated during the SI.

The eight temporary wells were constructed of one-inch nominal diameter, Schedule 40, flush-joint and threaded PVC casing placed in an open borehole immediately following the soil acquisition procedures detailed in Section 3.2.1. A polyester well sleeve was used to filter fine materials from the surrounding formation. Typical shallow temporary well construction details are shown on Figure 3-2. Construction details for the eight temporary wells are summarized in Table 3-4, and diagrams are provided in the Test Boring and Well Construction Records provided in Appendix B.

3.3.2 Monitoring Well Development

In order to remove fine-grained sediment from the screen and sandpack and to reestablish interconnection with the surrounding formation, each existing permanent monitoring well was redeveloped. The three existing shallow wells were redeveloped using a combination of surging and pumping techniques. Typically, 20 to 40 gallons of water were evacuated from each of the existing shallow wells, followed by 10 minutes of surging, then continued pumping. Groundwater recovered during well development was transferred into on-site storage drums (refer to Section 3.7). Pumping hoses, constructed of flexible high-density polyethylene, were used once and discarded to minimize the potential for cross contamination.

Three to five borehole volumes were removed from each well, where conditions permitted, until the groundwater appeared to be essentially sediment-free. Measurements of pH, specific conductance, and temperature were recorded after each volume was removed to assist in assessing well stabilization. Additionally, periodic flow and volume measurements were also recorded during development to evaluate flow rates of the shallow water-bearing zone.

3.3.3 Water Level Measurements

Static water level measurements were collected after well sampling activities had been completed. Measurements were recorded from top-of-casing (TOC) reference points marked on the PVC casing at each existing permanent and newly-installed temporary monitoring well. Water level measurements were collected on November 16, 1995, December 16, 1995, and February 24, 1996. Groundwater measurements were recorded to the nearest 0.01-foot using an electric measuring tape. Water level data from site monitoring wells and staff gauges were collected within a three-hour period. A summary of water level measurements is provided in Table 3-5.

3.3.4 Aquifer Testing

In-situ hydraulic conductivity tests (i.e., slug tests) were performed on each of the three existing permanent wells at Site 63 as part of the groundwater investigation. Aquifer testing results are provided in Appendix C. Both falling- and rising-head tests were performed to approximate individual well characteristics and to provide generalized information regarding surficial aquifer parameters within the study area.

3.3.5 Sampling Procedures

Groundwater samples were collected to assess whether contamination that may have resulted from previous disposal practices at Site 63 was present in the shallow aquifer. Based upon previous investigative results and historical records, the contaminants of potential concern were primarily metals.

Prior to groundwater purging, a water level measurement from each well was obtained according to procedures outlined in Section 3.3.3. The total well depth was also recorded from each well to the nearest 0.1-foot using a decontaminated steel tape. Water level and well depth measurements were used to calculate the volume of water in each well and the volume of water necessary to purge the well.

A minimum of three to five well volumes were purged from each well prior to sampling. Measurements of pH, specific conductance, temperature, and turbidity were taken after each well volume was purged to ensure that the groundwater characteristics had stabilized before sampling. These measurements were recorded in a field logbook and are provided in Table 3-6. Purge water was contained and handled as described in Section 3.7.

During the groundwater sampling event, a low flow well purging and sampling technique was employed. The sampling methodology was developed in response to conversations with USEPA Region IV personnel in Athens, Georgia. A peristaltic pump (GeoPump™), with the intake set two to three feet into the static water column, was used to purge each of the wells. While purging groundwater from each of the monitoring wells, a flow rate of less than 0.25 gallons per minute was maintained. Samples collected for both organic and metal analyses were obtained directly from the pump discharge. Dedicated sections of polyethylene and silicon pump-head tubing were used during purge and sampling activities at each well. Rinsate blanks were collected from the polyethylene and silicon tubing to verify that proper procedures had been followed.

The collection of groundwater samples incorporated procedures similar to those described for soil samples. Sample information, including well number, sample identification, time and date of sample collection, samplers, analytical parameters, and required laboratory turnaround time, was recorded in a field logbook and on the sample labels. Chain-of-custody documentation (provided in Appendix E) accompanied the samples to the laboratory.

3.3.6 Sampling Locations

Groundwater samples were collected from three existing shallow wells (63-GW01, 63-GW02, and 63-GW03) and the eight newly installed temporary wells (63-TW01 through 63-TW08) at Site 63. The locations of the newly installed temporary and existing monitoring wells are shown on Figure 3-3.

3.3.7 Analytical Program

Groundwater samples from the three existing shallow wells and the eight temporary wells were submitted for laboratory analysis from Site 63. Samples were analyzed for full TCL organics, TAL total metals, total suspended solids (TSS), and total dissolved solids (TDS). Table 3-7 provides a summary of groundwater samples submitted for laboratory analysis during the groundwater investigation. The groundwater samples were analyzed using Contract Laboratory Program (CLP) protocols and Level IV data quality.

3.3.8 Quality Assurance and Quality Control

Field QA/QC samples were also submitted for analyses during the groundwater investigation. These samples included trip blanks, equipment rinsates, and duplicates. Equipment rinsates were collected from the polyethylene and silicon tubing prior to sampling. Section 3.2.4 provides a summary of QA/QC samples collected during the investigation. Table 3-8 summarizes the QA/QC sampling program employed for the groundwater investigation conducted at Site 63.

3.3.9 Field Screening and Air Monitoring

Air monitoring and field screening procedures for volatile organic vapors implemented at Site 63 included the screening of well heads and the purged groundwater with a PID. Measurements obtained in the field were recorded in a field logbook. Prior to daily monitoring, the field instruments were calibrated and documentation was recorded in a field logbook and on calibration forms.

3.4 <u>Surface Water and Sediment Investigations</u>

An overview of the surface water and sediment investigations conducted at Site 63 is provided within this section. Surface water and sediment samples were collected at Site 63 during November of 1995. The subsections which follow describe the surface water and sediment sampling locations, sampling procedures, analytical program, and quality assurance and quality control program for Site 63.

3.4.1 Sampling Procedures

At each of the five surface water sampling stations, samples were collected by dipping a dedicated transfer container directly into the water. Surface water samples were then transferred to laboratory-prepared containers with the appropriate preservatives, depending upon the analyses requested. Samples to be analyzed for volatiles were obtained first; samples for additional analytical fractions were collected immediately following. Care was taken to avoid excessive agitation that could result in loss of VOCs. Water quality readings were taken at each sampling station (i.e., pH, dissolved oxygen, salinity, specific conductance, and temperature). The water quality readings compiled during the surface water and sediment investigation are presented in Table 3-9.

Sediment samples were collected below the aqueous layer by driving a sediment corer, equipped with a disposable tube, into the sediment. The first six inches of sediment at each station were submitted for analyses. The sediment was extruded from the disposable sampling tube and placed into the appropriate sample containers. Sampling containers were provided by the laboratory and certified to be contaminant free. The volatile fraction was collected first, followed by the remaining analytical parameters. Samples to be analyzed for TCL semivolatiles, pesticides, PCBs, total organic carbon, and TAL metals were thoroughly homogenized before the sample jars were filled. Surface water and sediment samples were collected at downstream sampling locations first. All sample locations were marked by placing a wooden stake at the nearest point along the bank.

3.4.2 Sampling Locations

A total of five surface water and five sediment samples were collected at Site 63 with each sampling station yielding one surface water and one sediment sample. Each of the sampling stations were located in an unnamed tributary to Mill Run, which borders the eastern portion of the study area. Figure 3-4 depicts the locations of the surface water and sediment sampling locations. Surface water samples were assigned the designation "SW" and "SD" was specified for identification of sediment samples.

3.4.3 Analytical Program

The analytical program at Site 63 was intended to assess the nature and extent of contamination in surface waters and sediments that may have resulted from past disposal practices. As a result, the analytical program focused on suspected contaminants of concern, based upon knowledge of suspected wastes and the overall quality of surface water and sediment. Both surface water and sediment samples were analyzed for full TCL organics and TAL metals. In addition to organic and inorganic analyses, sediment samples were also analyzed for TOC and grain size. A summary of the surface water and sediment analytical program is provided in Table 3-10.

3.4.4 Quality Assurance and Quality Control

Field QA/QC samples were collected during the surface water and sediment investigation at Site 63, including duplicate samples, equipment rinsate samples, and trip blanks. Table 3-11 provides a summary of the QA/QC sampling program conducted during the surface water and sediment investigation. Section 3.2.4 lists the various QA/QC samples collected during the sampling program at Site 63 and the frequency at which they were obtained.

3.5 Ecological Investigation

An ecological investigation, consisting of a habitat evaluation, was conducted at Site 63. During the habitat evaluation, dominant vegetation types and species were qualitatively assessed in the field. Based on previous habitat evaluations conducted in similar habitats at MCB, Camp Lejeune, species expected to live at the site were identified. Amphibians, reptiles, birds, and mammals were also identified as visual sightings or evidence allowed In addition, photographs were used to determine dominant vegetation types and species. From this information, ecological communities were established and biohabitat maps developed (refer to Section 2.0).

3.6 Decontamination Procedures

Decontamination procedures performed in the field were initiated in accordance with USEPA Region IV SOPs. Sampling equipment was divided into two decontamination groups, heavy equipment and routine sample collection equipment. Heavy equipment included the GeoProbe™ rig and stainless steel sampling rods. Routine sample collection equipment included stainless steel core barrels (used with the GeoProbe™) and stainless steel spoons.

The following procedures were implemented for heavy equipment:

- Removal of caked-on soil with brush
- Steam clean with high-pressure steam
- Air dry

The following procedures were implemented for routine sample collection equipment:

- Clean with distilled water and laboratory detergent (Liquinox soap solution)
- Rinse thoroughly with distilled water
- Rinse twice with isopropyl alcohol
- Air dry
- Wrap in aluminum foil, if appropriate

Temporary decontamination pads, constructed of wood and plastic, were constructed to prevent spillage of fluids onto the ground surface. Decontamination fluids generated during the field program were containerized and handled according to the procedures outlined in Section 3.7.

3.7 Investigation Derived Waste (IDW) Management

Field investigation activities at Site 63 resulted in the generation of various IDW. This IDW included well development and purge water and solutions used to decontaminate non-disposable sampling equipment. The general management techniques utilized for the IDW were:

- Collection and containerization of IDW material.
- Temporary storage of IDW while awaiting confirmatory analytical data.
- Final disposal of aqueous and solid IDW material.

The management of the IDW was performed in accordance with guidelines developed by the USEPA Office of Emergency and Remedial Response, Hazardous Site Control Division (USEPA, 1992). Liquid IDW was returned, based on confirmatory analytical data, to its respective source area. Appendix F provides information regarding the management and disposal of the IDW.

3.8 References

American Society for Testing and Materials (ASTM). 1993. Standard Practice for Description and Identification of Soils (Visual Manual Procedure). ASTM D-2488-93. American Society for Testing and Materials, Philadelphia, Pennsylvania.

Baker Environmental, Inc. January 1994. Site Inspection Report - Site 63, Verona Loop Dump. Final. Prepared for the Department of the Navy, Naval Facilities Engineering Command, Atlantic Division, Norfolk, Virginia. January 1994.

Baker Environmental, Inc. 1995. Remedial Investigation/Feasibility Study Project Plans for Operable Unit No. 13 (Site 63), Marine Corps Base Camp Lejeune, North Carolina. Final. Prepared for the Department of the Navy, Naval Facilities Engineering Command, Atlantic Division, Norfolk, Virginia. September 1995.

Naval Energy and Environmental Support Activity (NEESA). 1988. Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation Restoration Program. Department of the Navy, Naval Energy and Environmental Support Activity, Port Hueneme, California. NEESA 20.2-047B.

United States Environmental Protection Agency (USEPA). 1991. National Functional Guidelines for Organic Data Review. Draft. USEPA Contract Laboratory Program. June 1991.

United States Environmental Protection Agency (USEPA). 1992. Guide to Management of Investigation-Derived Wastes. "Standard Default Exposure Factors" Interim Final. Office of Emergency and Remedial Response Hazardous Site Control Division. Washington, D.C. OS-220W. April 1992.

Water and Air Research, Inc. (WAR). 1983. Initial Assessment Study of Marine Corps Base Camp Lejeune, North Carolina. Prepared for the Department of the Navy, Naval Energy and Environmental support Activity, Port Hueneme, California. April 1983.

SECTION 3.0 TABLES

TABLE 3-1

SOIL SAMPLE SUMMARY
TEST BORINGS
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth of Borehole (feet, below ground surface)	Sampling Interval (feet, below ground surface)	Analytical Parameters						
			TCL Pest/PCB	TCL VOC	TCL SVOC	TAL Metals	Engineering Properties[(1)]	Duplicate Sample	MS/MSD
63-SB01	13	0-1	X	X	X	X			
		7-9	X	X	X	X			
63-SB02	13	0-1	X	X	X	X			
		7-9	X	X	X	X			
63-SB03	15	0-1	X	X	X	X			
		11-13	X	X	X	X		X	
63-SB04	9	0-1	X	X	X	X			
		5-7	X	X	X	X			
63-SB05	15	0-1	X	X	X	X			
		5-7	X	X	X	X			
		11-13	X	X	X	X			
63-SB06	11	0-1	X	X	X	X		X	
		1-3	X	X	X	X			
63-SB07	11	0-1	X	X	X	X			
		7-9	X	X	X	X			
63-SB08	19.5	0-1	X	X	X	X			
		9-11	X	X	X	X			
		13-15	X	X	X	X			
63-SB09	26.5	0-1	X	X	X	X			
		5-7	X	X	X	X		X	X
		11-13	X	X	X	X			
63-SB10	7	0-1	X	X	X	X			
		3.5	X	X	X	X			
63-SB11	11	0-1	X	X	X	X		X	X
		9-11	X	X	X	X			
63-SB12	11	0-1	X	X	X	X	X		
		7-9	X	X	X	X			
63-SB13	15	0-1	X	X	X	X			
		5-7	X	X	X	X			
		9-11	X	X	X	X			

TABLE 3-1 (Continued)

SOIL SAMPLE SUMMARY
TEST BORINGS
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth of Borehole (feet, below ground surface)	Sampling Interval (feet, below ground surface)	Analytical Parameters						
			TCL Pest/PCB	TCL VOC	TCL SVOC	TAL Metals	Engineering Properties(1)	Duplicate Sample	MS/MSD
63-SB14	9	0-1	X	X	X	X			
		5-7	X	X	X	X			
63-SB15	11	0-1	X	X	X	X			
		7-9	X	X	X	X			
63-SB16	7	0-1	X	X	X	X			
		3-5	X	X	X	X			
63-SB17	9	0-1	X	X	X	X			
		5-7	X	X	X	X			
63-SB18	17	0-1	X	X	X	X			
		9-11	X	X	X	X			
63-SB19	9	0-1	X	X	X	X			
		5-7	X	X	X	X			
63-SB20	5	0-1	X	X	X	X			
		1-3	X	X	X	X			
63-SB21	9	0-1	X	X	X	X			
		5-7	X	X	X	X			
63-SB22	9	0-1	X	X	X	X	X		
		5-7	X	X	X	X			
63-SB23	9	0-1	X	X	X	X		X	X
		5-7	X	X	X	X			
63-SB24	9	0-1	X	X	X	X		X	X
		5-7	X	X	X	X		X	
63-SB25	9	0-1	X	X	X	X		X	
		5-7	X	X	X	X			
63-SB26	9	0-1	X	X	X	X			
		5-7	X	X	X	X			
63-SB27	7	0-1	X	X	X	X			
		3-5	X	X	X	X			
63-SB28	7.5	0-1	X	X	X	X			
		3-5	X	X	X	X			
63-SB29	9	0-1	X	X	X	X			
		5-7	X	X	X	X			

TABLE 3-1 (Continued)

SOIL SAMPLE SUMMARY
TEST BORINGS
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth of Borehole (feet, below ground surface)	Sampling Interval (feet, below ground surface)	Analytical Parameters						
			TCL Pest/PCB	TCL VOC	TCL SVOC	TAL Metals	Engineering Properties[1]	Duplicate Sample	MS/MSD
63-SB30	9	0-1	X	X	X	X			
		5-7	X	X	X	X			
63-SB31	11	0-1	X	X	X	X		X	
		7-9	X	X	X	X			
63-SB32	7	0-1	X	X	X	X			
		3-5	X	X	X	X			
63-SB33	7	0-1	X	X	X	X			
		3-5	X	X	X	X			
63-SB34	13	0-1	X	X	X	X			
		9-11	X	X	X	X			
63-SB35	1	0-1	X	X	X	X			
63-SB36	7	0-1	X	X	X	X			
		3-5	X	X	X	X			
63-SB37	13	0-1	X	X	X	X			
		7-9	X	X	X	X			
63-SB38	5	0-1	X	X	X	X			
		3-5	X	X	X	X			

Notes:

(1) Engineering Properties include cation exchange capacity and total organic carbon.

TABLE 3-2

SOIL SAMPLE SUMMARY
MONITORING WELL TEST BORINGS
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth of Borehole (feet, below ground surface)	Sampling Interval (feet, below ground surface)	Analytical Parameters						
			TCL Pest/PCB	TCL VOC	TCL SVOC	TAL Metals	Grain Size	Duplicate Sample	MS/MSD
63-TW01	11	0-1	X	X	X	X	X		
		1-3	X	X	X	X			
63-TW02	16	0-1	X	X	X	X			
		7-9	X	X	X	X			
63-TW03	15.5	0-1	X	X	X	X	X		
		5-7	X	X	X	X			
63-TW04	14	0-1	X	X	X	X			
		5-7	X	X	X	X	X		
63-TW05	12	0-1	X	X	X	X			
		3-5	X	X	X	X			
63-TW06	13	0-1	X	X	X	X			
		3-5	X	X	X	X		X	
63-TW07	12	0-1	X	X	X	X			
		1-3	X	X	X	X			
63-TW08	9	0-1	X	X	X	X			
		5-7	X	X	X	X			

TABLE 3-3

QUALITY ASSURANCE/QUALITY CONTROL SAMPLING PROGRAM
SOIL INVESTIGATION
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

QA/QC Sample[1]	Frequency of Collection	Number of Samples	Analytical Parameters
Trip Blanks[2]	One per cooler	5	TCL Volatiles
Field Blanks[3]	One per event	1	TCL VOC, TCL SVOC, TCL Pest/PCB, TAL Metals
Equipment Rinsates[4]	One per day	5	TCL VOC, TCL SVOC, TCL Pest/PCB, TAL Metals
Field Duplicates[5]	10% of sample frequency	6	TCL VOC, TCL SVOC, TCL Pest/PCB, TAL Metals

Notes:

(1) QA/QC sample types defined in Section 3.2.4 of text.
(2) Trip blanks submitted with coolers which contained samples for volatile analysis. Samples analyzed for TCL volatiles only.
(3) Field blank collected during the investigation from water source used for decontamination.
(4) Equipment rinsates collected from various sampling equipment used (e.g., stainless steel spoons).
(5) Field duplicate samples presented in Appendix J.

TABLE 3-4

SUMMARY OF WELL CONSTRUCTION DETAILS
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well No.	Date Installed	Top of PVC Casing Elevation (feet, MSL)	Ground Surface Elevation (feet, MSL)	Boring Depth (feet, below ground surface)	Well Depth (feet, below ground surface)	Screen Interval Depth (feet, below ground surface)
63-TW01	11/12/95	40.62	38.44	11	11	1.0-11.0
63-TW02	11/11/95	46.38	44.13	16	16	6.0-16.0
63-TW03	11/12/95	45.77	43.20	15.5	15.5	5.5-15.5
63-TW04	11/10/95	50.92	48.48	14	13	3.0-13.0
63-TW05	11/10/95	50.80	47.52	12	12	7.0-12.0
63-TW06	11/10/95	33.07[1]	31.90	12	13	7.0-12.0
63-TW07	11/11/95	41.53	38.00	12	12	2.0-12.0
63-TW08	11/09/95	38.85	36.76	7.5	7.5	2.5-7.5

Notes:

MSL = mean sea level
(1) PVC casing is loose
Horizontal positions are referenced to N.C. State Plane Coordinate System (Vertical Datum NGVD29).

TABLE 3-5

SUMMARY OF WATER LEVEL MEASUREMENTS
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well ID	Reference Elevation[1]	SWL Nov. 16, 1995	SWL Dec. 16, 1995	SWL Feb. 24, 1996	SWE Nov. 16, 1995	SWE Dec. 16, 1995	SWE Feb. 24, 1996
63-GW01	51.28	9.16	10.77	9.88	42.12	40.51	41.40
63-GW02	48.42	9.56	10.37	9.70	38.86	38.05	38.72
63-GW03	47.54	NA	9.26	7.71	NA	38.28	39.83
63-TW01	40.62	9.30	10.10	6.54	31.32	30.52	34.08
63-TW02	46.38	10.88	12.20	10.42	35.50	34.18	35.96
63-TW03	45.77	10.63	11.91	10.12	35.14	33.86	35.65
63-TW04	50.92	9.00	10.10	9.34	41.92	40.82	41.58
63-TW05	50.80	7.13	7.95	7.26	43.67	42.85	43.54
63-TW06[2]	33.07	NA	NA	NA	NA	NA	NA
63-TW07	41.53	8.99	10.15	8.78	32.54	31.38	32.75
63-TW08	38.85	5.88	7.48	6.20	32.97	31.37	32.65
63-SG01[3]	29.84	2.81	1.72	1.78	29.31	28.22	28.28
63-SG02[3]	24.73	1.16	1.20	1.18	22.55	22.59	22.57

Notes:

(1) Top of PVC well casing (in feet above mean sea level [MSL])
(2) PVC casing is loose - unreliable data
(3) Staff gauge
SWL = Static water level taken from top of PVC well casing
SWE = Static water elevation (in feet above MSL)
NA = Data not available

TABLE 3-6

SUMMARY OF GROUNDWATER FIELD PARAMETERS
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well Number	Date of Measurement	Depth of Well (ft)	Purge Volume (gallons)	Well Volume	Specific Conductance (micromhos/cm)	Temperature (°C)	pH (SU)	Turbidity (NTU)	Dissolved oxygen (mg/L)
63-TW01	11/12/95	11	1	1.0	73	9.0	6.01	>200	11.0
				1.3	153	15.2	6.16	>200	9.8
				1.7	NA	NA	NA	>200	NA
				2.0	NA	NA	NA	173	NA
				2.1	NA	NA	NA	74	NA
				2.2	NA	NA	NA	50	NA
				2.3	NA	NA	NA	NA(4)	NA
				2.4	NA	NA	NA	NA	NA
				2.5	NA	NA	NA	49.7	NA
				2.6	NA	NA	NA	31	NA
				2.7	136	13.0	6.46	14.5	NA
				2.8	NA	NA	NA	13	NA
				3.0	136	13.5	6.46	4.4	NA

TABLE 3-6 (Continued)

SUMMARY OF GROUNDWATER FIELD PARAMETERS
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well Number	Date of Measurement	Depth of Well (ft)	Purge Volume (gallons)	Well Volume	Specific Conductance (micromhos/cm)	Temperature (°C)	pH (SU)	Turbidity (NTU)	Dissolved oxygen (mg/L)
63-TW02	11/13/95	16	2	1.0	92	14.2	4.98	>200	7.0
				1.5	151	14.4	4.52	>200	5.6
				2.0	146	14.7	4.43	>200	6.2
				2.5	146	15.0	4.40	30	5.8
				3.0	148	15.2	4.43	16	5.6
				3.3	147	14.9	4.42	8.6	6.0
				3.7	147	14.5	4.41	8.6	6.0
				4.0	149	15.5	4.42	3.3	6.0
				4.3	147	15.1	4.44	2.5	6.0
				4.7	NA	NA	NA	2.4	NA
				5.0	NA	NA	NA	2	NA
63-TW03	11/13/95	15.5	1.4	1.0	126	15.8	4.35	42	4.0
				1.5	128	15.8	4.20	10.3	3.4
				2.0	127	15.8	4.13	10	3.4
				2.5	127	16.1	4.13	2	3.4
				3.0	127	16.1	4.12	0.8	3.4
				3.5	128	16.3	4.12	0.4	3.4
				4.0	126	16.4	4.11	0.8	3.4

TABLE 3-6 (Continued)

SUMMARY OF GROUNDWATER FIELD PARAMETERS
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well Number	Date of Measurement	Depth of Well (ft)	Purge Volume (gallons)	Well Volume	Specific Conductance (micromhos/cm)	Temperature (°C)	pH (SU)	Turbidity (NTU)	Dissolved oxygen (mg/L)
63-TW04	11/13/95	13	1.7	1.0	65.5	16.8	4.53	20.3	4.8
					63.4	15.3	4.74	6.2	3.2
				2.0	55.6	17.6	4.79	3.5	3.2
				3.0	55.2	17.9	4.81	3.3	3.1
				4.0	56.3	17.5	4.80	2.7	3.2
				5.0	55.4	17.1	4.80	2.5	3.1
63-TW05	11/13/95	12	2.8	1.0	67	17.7	4.76	>200	3.6
				1.5	72	17.7	5.24	>200	3.9
				2.0	81	17.5	5.66	>200	3.4
				2.5	94	17.5	5.84	115	3.1
				3.0	97	17.7	5.83	57.2	3.2
				3.5	101	17.5	5.93	57.5	2.9
				4.0	106	17.7	5.96	56.6	2.9
				4.5	107	17.4	5.99	49.2	2.9
				5.0	110	17.6	5.99	40.5	2.8
				5.5	113	17.4	6.10	39.4	2.8
				6.0	130	17.6	6.23	48.6	2.7
				6.5	127	17.4	6.16	44.4	2.5
				7.0	122	17.5	6.07	41.8	2.5

TABLE 3-6 (Continued)

SUMMARY OF GROUNDWATER FIELD PARAMETERS
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well Number	Date of Measurement	Depth of Well (ft)	Purge Volume (gallons)	Well Volume	Specific Conductance (micromhos/cm)	Temperature (°C)	pH (SU)	Turbidity (NTU)	Dissolved oxygen (mg/L)
63-TW06	11/13/95	12	2	1.0	91	17.2	4.68	183.5	3.2
				1.5	92	17.4	4.72	193.3	2.7
				2.0	92	17.3	4.71	188.5	2.5
				3.0	91	17.1	4.71	78.0	2.6
				4.0	91	16.9	4.69	66.9	2.5
				5.0	92	17.2	4.71	16.7	2.5
				6.0	92	17.0	4.71	21.5	2.8
				6.5	92	16.2	4.71	94.0	2.7
				7.0	92	16.6	4.70	80.1	3.0
				8.0	92	16.2	4.70	17.0	2.9
				9.0	NA	NA	NA	40.7	NA
				9.3	NA	NA	NA	8.5	NA
				9.7	NA	NA	NA	10.9	NA
				10.0	NA	NA	NA	20.3	NA

TABLE 3-6 (Continued)

SUMMARY OF GROUNDWATER FIELD PARAMETERS
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well Number	Date of Measurement	Depth of Well (ft)	Purge Volume (gallons)	Well Volume	Specific Conductance (micromhos/cm)	Temperature (°C)	pH (SU)	Turbidity (NTU)	Dissolved oxygen (mg/L)
63-TW07	11/15/95	12	1.6	1.0	172	13.8	6.21	>200	4.9
				1.2	159	12.4	6.22	>200	5.5
				1.6	158	13.5	6.09	99	5.0
				1.8	156	13.0	6.05	32.4	4.9
				2.0	158	13.4	6.02	17	4.7
				2.5	158	13.9	5.99	6.9	4.5
				3.0	160	13.7	5.95	4.2	4.4
				3.5	159	15.6	5.92	3.5	4.6
				4.0	158	14.2	5.87	2.3	4.4
63-TW08	11/14/95	7.5	3	4.3	56	15.7	4.77	>200	2.7
				4.7	53	15.1	4.74	161	3.7
				5.0	53	15.6	4.72	39.4	3.7
				6.0	50	15.7	4.74	105	3.5
				7.0	51	15.3	4.72	65	3.5
				9.0	51	16.3	4.72	22.4	3.5
				10.0	52	16.1	4.75	37.6	3.1
				11.0	52	16.2	4.73	16.4	3.3
				12.0	52	15.7	4.74	14.4	3.4
				13.0	50	15.7	4.74	14.4	3.5
				15.0	50	15.7	4.73	10.5	3.4
				16.0	NA	NA	NA	10.7	NA

TABLE 3-6 (Continued)

SUMMARY OF GROUNDWATER FIELD PARAMETERS
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well Number	Date of Measurement	Depth of Well (ft)	Purge Volume (gallons)	Well Volume	Specific Conductance (micromhos/cm)	Temperature (°C)	pH (SU)	Turbidity (NTU)	Dissolved oxygen (mg/L)
63-GW01	11/15/95	18.21	4.5	1.0	39	16.2	5.15	77.7	8.3
				1.1	37	16.1	5.24	97.4	7.2
				1.3	37	16.3	5.23	99.3	6.0
				1.5	37	16.0	5.23	77.6	5.9
				1.7	37	15.8	5.31	42.2	5.2
				1.8	37	16.8	5.29	36.5	5.1
				1.9	37	16.3	5.25	18.9	4.7
				2.0	37	16.1	5.28	14.0	4.4
				2.3	37	16.3	5.28	10.0	4.5
				2.5	37	16.5	5.25	8.5	4.3
				2.7	36	16.6	5.27	8.4	4.2
				3.0	36	16.3	5.27	8.6	4.3
63-GW02	11/15/95	16.26	3.3	1.0	286	13.6	5.88	10.5	3.5
				1.3	298	13.5	5.91	9.0	2.9
				1.5	295	13.9	5.91	9.8	2.7
				1.7	307	13.5	5.96	10.5	2.6
				2.0	300	13.8	5.94	9.5	2.4
				1.3	306	13.4	5.98	9.8	2.5
				1.5	309	13.4	5.98	10.5	2.4
				1.7	319	13.6	6.01	13.4	2.6
				3.0	319	13.7	6.01	13.1	2.7
				3.5	NA	NA	NA	10.4	NA

TABLE 3-6 (Continued)

SUMMARY OF GROUNDWATER FIELD PARAMETERS
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well Number	Date of Measurement	Depth of Well (ft)	Purge Volume (gallons)	Well Volume	Specific Conductance (micromhos/cm)	Temperature (°C)	pH (SU)	Turbidity (NTU)	Dissolved oxygen (mg/L)
63-GW03	11/15/95	16.05	2.7	1.0	92	15.1	4.34	23.2	11.8
				1.1	94	15.0	4.30	30.0	11.2
				1.2	96	15.1	4.32	19.4	11.1
				1.3	99	14.9	4.36	10.7	11.2
				1.5	101	15.1	4.40	3.9	11.3
				1.6	103	15.0	4.47	2.3	8.8
				1.7	103	15.1	4.48	2.3	8.4
				1.8	103	14.8	4.49	2.1	8.5
				1.9	105	15.3	4.51	1.0	8.6
				2.0	105	15.4	4.51	0.9	8.5
				2.3	103	14.6	4.51	1.1	8.5
				2.7	103	15.1	4.52	1.2	8.5
				3.0	104	15.0	4.50	1.1	8.5

Notes:

SU = Standard Units
TU = Turbidity Units

TABLE 3-7

GROUNDWATER SAMPLING SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Analytical Parameters							
	TCL VOA	TCL SVOA	TCL Pest/PCB	TAL Metals	Total Suspended Solids	Total Dissolved Solids	Duplicate	MS/MSD
63-TW01	X	X	X	X	X	X		
63-TW02	X	X	X	X	X	X		
63-TW03	X	X	X	X	X	X		
63-TW04	X	X	X	X	X	X	X	
63-TW05	X	X	X	X	X	X		
63-TW06	X	X	X	X	X	X		
63-TW07	X	X	X	X	X	X		
63-TW08	X	X	X	X	X	X		
63-GW01	X	X	X	X	X	X	X	X
63-GW02	X	X	X	X	X	X		
63-GW03	X	X	X	X	X	X		

TABLE 3-8

QUALITY ASSURANCE/QUALITY CONTROL SAMPLING PROGRAM
GROUNDWATER INVESTIGATION
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

QA/QC Sample[1]	Frequency of Collection	Number of Samples	Analytical Parameters
Trip Blanks[2]	One per cooler	3	TCL Volatiles
Field Blanks[3]	One per event	1	TCL VOC, TCL SVOC, TCL Pest/PCB, TAL Metals
Equipment Rinsates[4]	One per day	2	TCL VOC, TCL SVOC, TCL Pest/PCB, TAL Metals
Field Duplicates[5]	10% of sample frequency	1	TCL VOC, TCL SVOC, TCL Pest/PCB, TAL Metals

Notes:

(1) QA/QC sample types defined in Section 3.2.4 of text.
(2) Trip blanks submitted with coolers which contained samples for volatile analysis. Samples analyzed for TCL volatiles only.
(3) Field blank collected during the investigation from water source used for decontamination.
(4) Equipment rinsates collected from various sampling equipment used (e.g., polyethylene and silicon tubing).
(5) Field duplicate samples presented in Appendix J.

TABLE 3-9

SUMMARY OF SURFACE WATER FIELD PARAMETERS
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Station	Temperature (°C)	pH (SU)	Dissolved Oxygen (mg/L)	Specific Conductance (micromhos/cm)
63-SW01	14.8	3.99	4.7	73.6
63-SW02	13.4	3.9	4.7	73
63-SW03	13	3.84	4.3	72
63-SW04	12.2	3.91	7.2	68.9
63-SW05	12.9	3.62	7.5	84.1

Notes:

SU = Standard Units

TABLE 3-10

SURFACE WATER AND SEDIMENT SAMPLING SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Sample Matrix	Sample Depth	TCL VOC	TCL SVOC	TCL Pest/PCB	TAL Metals	Grain Size	TOC	Duplicate	MS/MSD
63-SW/SD01	SW	NA	X	X	X	X				
	SD	0-6"	X	X	X	X	X	X		
63-SW/SD02	SW	NA	X	X	X	X				
	SD	0-6"	X	X	X	X	X	X		
63-SW/SD03	SW	NA	X	X	X	X			X	X
	SD	0-6"	X	X	X	X	X	X	X(1)	X(1)
63-SW/SD04	SW	NA	X	X	X	X				
	SD	0-6"	X	X	X	X	X	X		
63-SW/SD05	SW	NA	X	X	X	X				
	SD	0-6"	X	X	X	X	X	X		

Notes:

SW = Surface Water
SD = Sediment
NA = Not Applicable
TOC = Total Organic Carbon
(1) TOC and grain size not analyzed for duplicate and MS/MSD samples.

TABLE 3-11

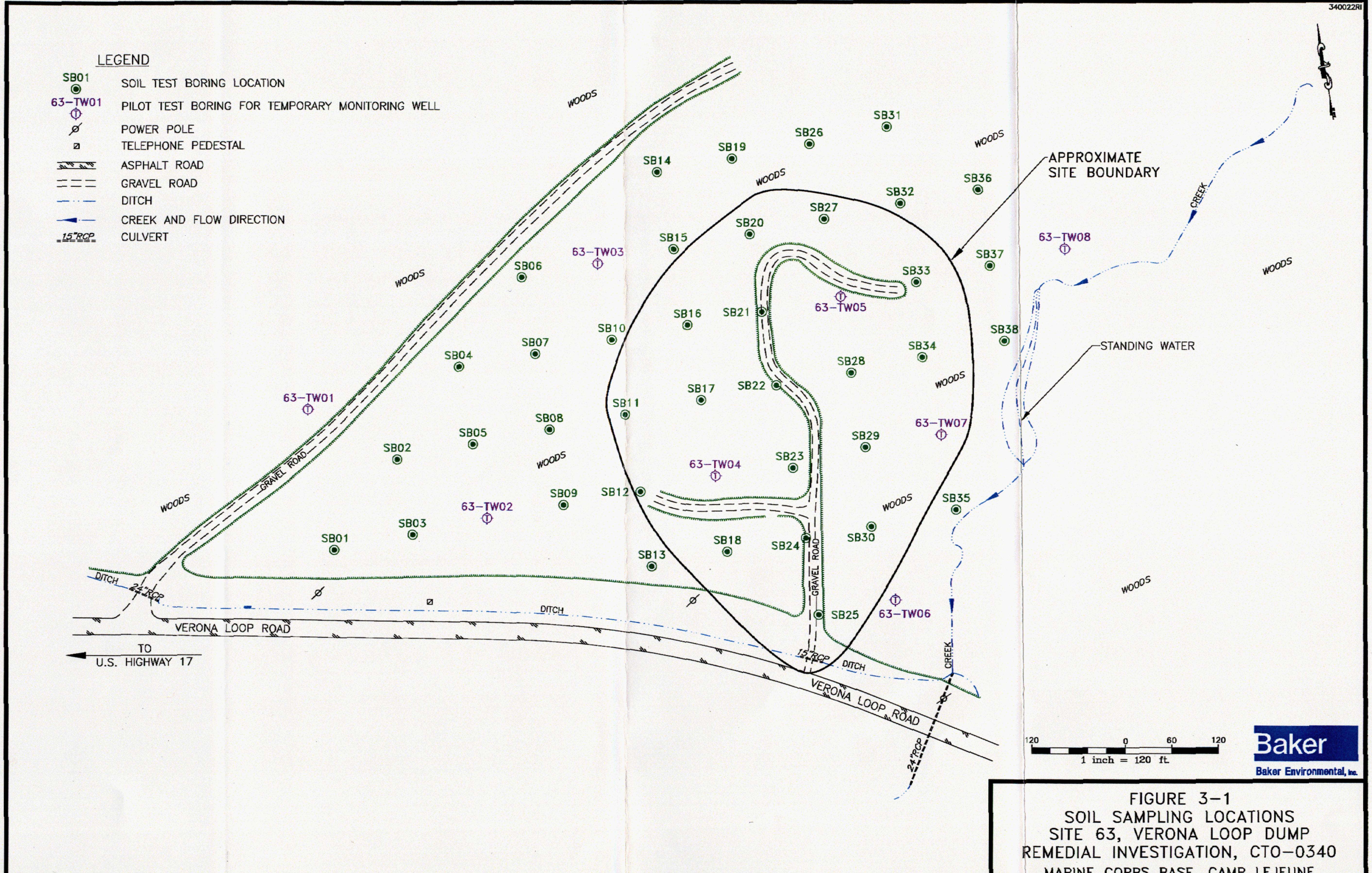
QUALITY ASSURANCE/QUALITY CONTROL SAMPLING PROGRAM
SURFACE WATER AND SEDIMENT INVESTIGATION
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

QA/QC Sample(1)	Frequency of Collection	Number of Samples	Analytical Parameters
Trip Blanks(2)	One per cooler	1	TCL Volatiles
Field Blanks(3)	One per event	1	TCL VOC, TCL SVOC, TCL Pest/PCB, TAL Metals
Equipment Rinsates(4)	One per day	1	TCL VOC, TCL SVOC, TCL Pest/PCB, TAL Metals
Field Duplicates(5)	10% of sample frequency	2	TCL VOC, TCL SVOC, TCL Pest/PCB, TAL Metals

Notes:

(1) QA/QC sample types defined in Section 3.2.4 of text.
(2) Trip blanks submitted with coolers which contained samples for volatile analysis. Samples analyzed for TCL volatiles only.
(3) Field blank collected during the investigation from water source used for decontamination.
(4) Equipment rinsates collected from various sampling equipment used (e.g., sediment corer and acetate liner).
(5) Duplicate samples presented in Appendix J.

SECTION 3.0 FIGURES

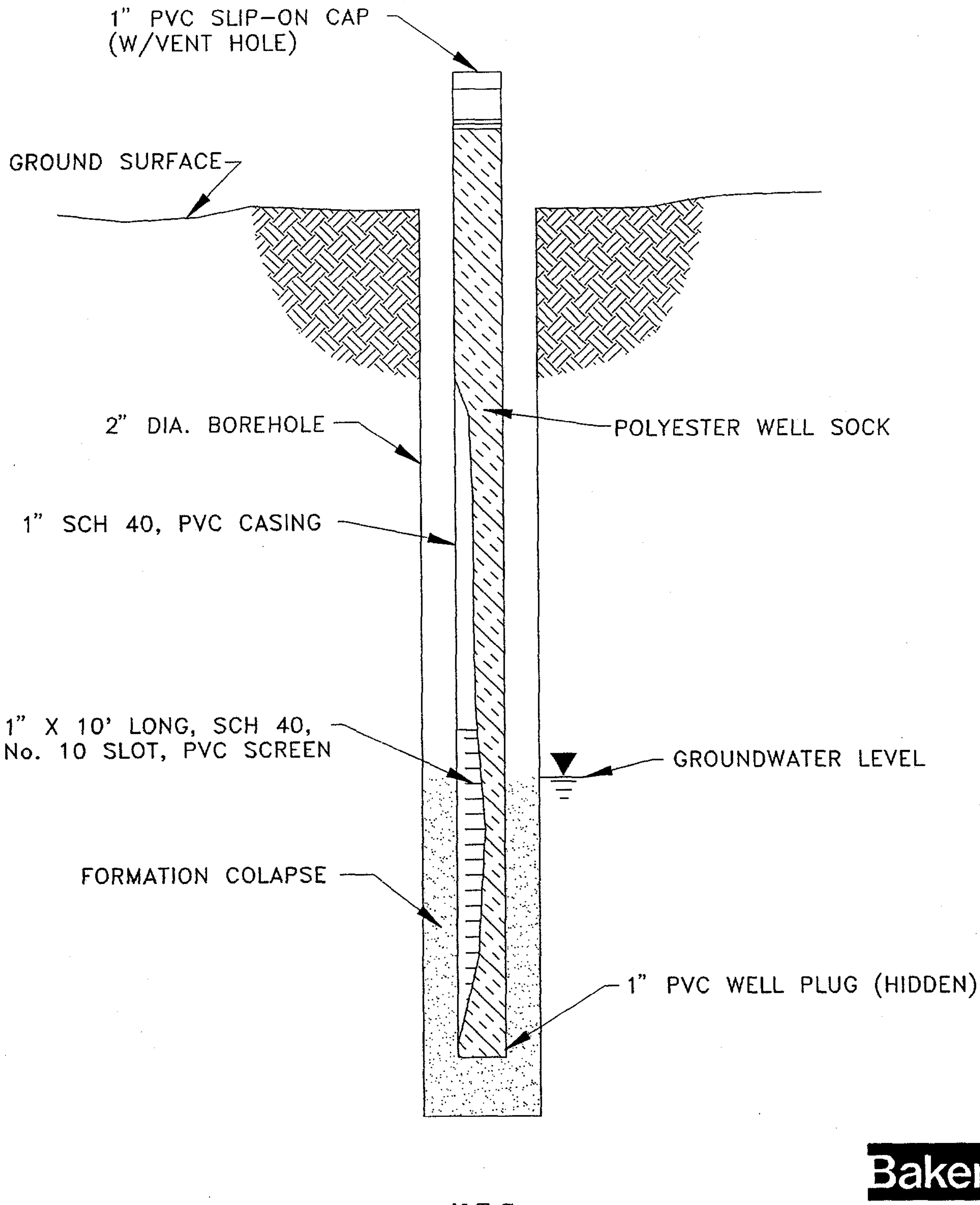


SOURCE: LANTDIV, 1992
SURVEY: W.K. DICKSON & ASSOC., 1995

FIGURE 3-1
SOIL SAMPLING LOCATIONS
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01708N19Y

340025RI



N.T.S.

Baker
Baker Environmental, Inc.

FIGURE 3-2
TEMPORARY SHALLOW GROUNDWATER
MONITORING WELL CONSTRUCTION DIAGRAM
REMEDIAL INVESTIGATION, CTO-0340

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

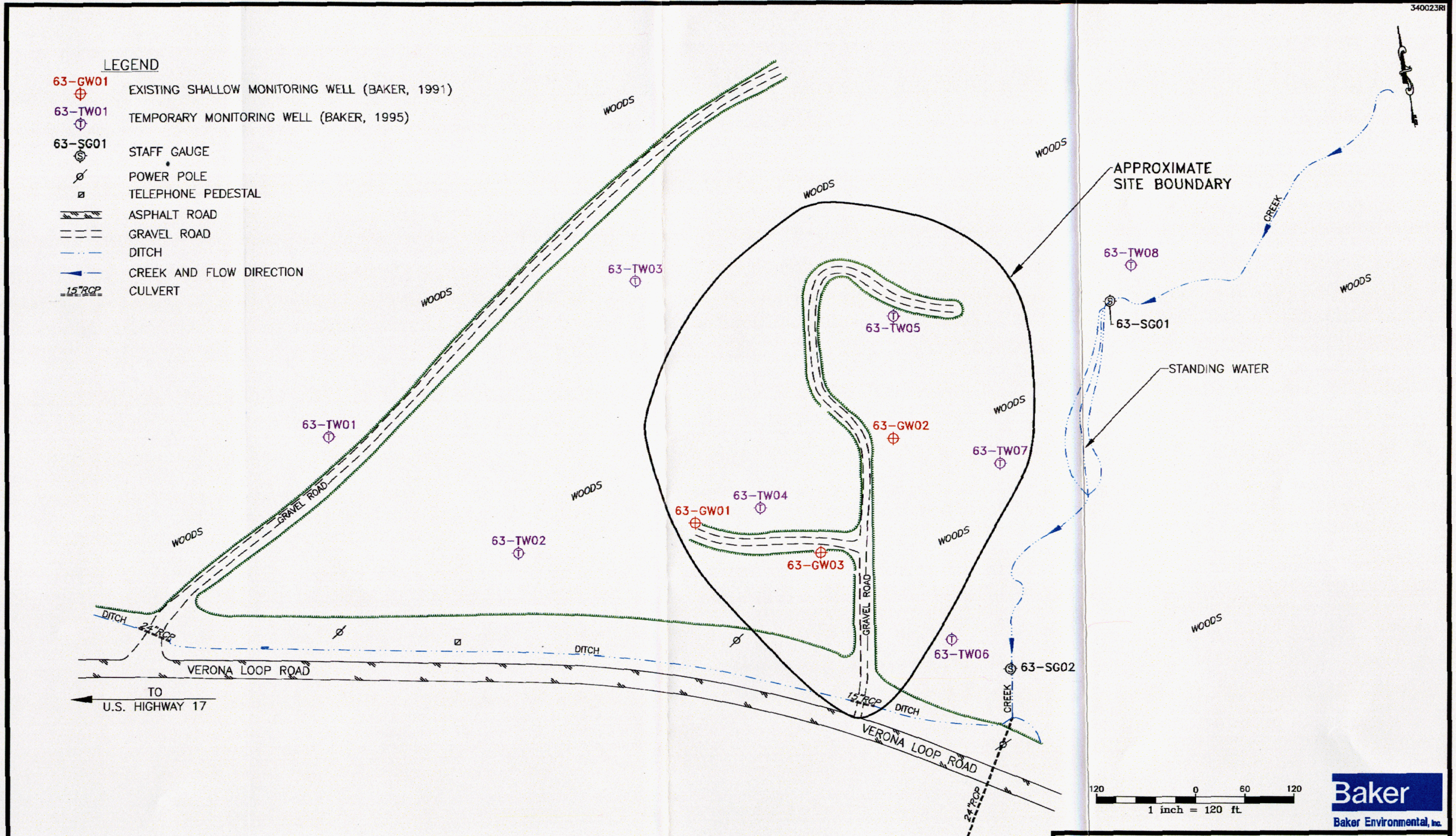


FIGURE 3-3
MONITORING WELL LOCATIONS
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

SOURCE: LANTDIV, 1992
SURVEY: W.K. DICKSON & ASSOC., 1995

01708N20Y

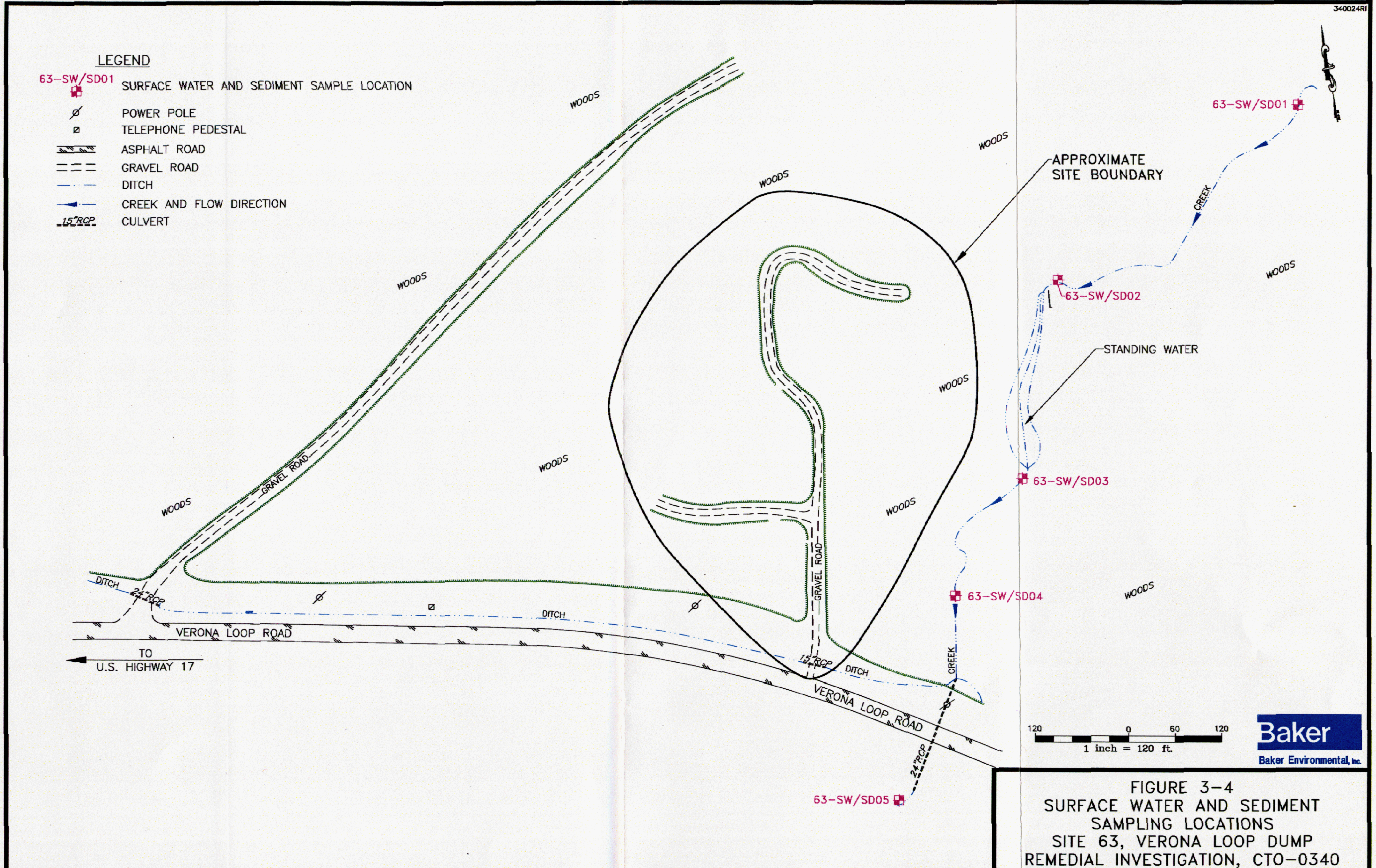


FIGURE 3-4
SURFACE WATER AND SEDIMENT
SAMPLING LOCATIONS
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

SOURCE: LANTDIV, 1992
SURVEY: W.K. DICKSON & ASSOC., 1995

01708N21Y

4.0 NATURE AND EXTENT OF CONTAMINATION

This section presents the nature and extent of contamination at OU No.13, Site 63. The objective of this section is to characterize the nature and extent of contamination which may be present as a result of past waste management activities. The characterization of contaminants at Site 63 was performed by sampling and performing laboratory analysis of soil, groundwater, surface water, and sediment environmental media. Appendices G through L present the Sampling Summaries; Data and Frequency Summaries; Statistical Summaries; Field Duplicate Summaries; Quality Assurance and Quality Control Summaries; and Grain Size, Total Organic Carbon, and Wet Chemistry Analytical Results for the various media at Site 63.

4.1 Data Quality

The majority of data generated during the RI was submitted for third-party validation; grain size, total organic carbon, and wet chemistry results were not validated. Procedures stipulated by the National Functional Guidelines for Organic (USEPA, 1991a) and Inorganic Analyses (USEPA, 1988) were observed during the validation process. Validation of the analytical data serves to reduce the inherent uncertainties associated with its usability. Data qualified as "J" were retained as estimated. Estimated analytical results within a data set are common and considered to be usable by the USEPA (USEPA, 1989). Data may be qualified as estimated for several reasons including an exceedance of holding times, high or low surrogate recovery, or intra-sample variability. In addition, values may be assigned an estimated "J" qualifier if the reported value is below the Contract Required Detection Limit (CRDL) or the Contract Required Quantitation Limit (CRQL). Data assigned a rejected "R" qualifier was excluded from the usable data set. Under these conditions estimated positive results were designated with "J" qualifiers and rejected data were assigned "R" qualifiers.

4.1.1 Data Management and Tracking

The management and tracking of data, from time of field collection to receipt of the validation report, is of primary importance to the overall quality of laboratory analytical results. Field samples and their corresponding analyses were recorded on chain-of-custody forms, provided in Appendix E. Chain-of-custody forms were compared to the Field Sampling and Analysis Plan (Baker, 1995); this comparison was used to demonstrate that appropriate laboratory analyses had been requested. Upon receipt of laboratory analytical results, a further comparison was performed to demonstrate that each sample received by the laboratory was analyzed for the correct parameters. Finally, the validation report was compared to the requested laboratory analyses.

The management and tracking of data was used to monitor the following items:

- Identify and correct chain-of-custody discrepancies prior to laboratory analysis
- Verify the receipt of all samples by the laboratory
- Confirm that requested sample analyses and validation were performed
- Ensure the delivery of a complete data package

4.2 Non-Site Related Analytical Results

Many of the organic compounds and inorganic analytes detected in environmental media at Site 63 may be attributable to non-site related conditions or activities. Two primary sources of non-site related analytical results include laboratory contaminants and naturally occurring inorganic species. In addition, non-site related operational activities and conditions may contribute to "on-site" contamination. A discussion of non-site related analytical results for Site 63 is provided in the subsections which follow.

4.2.1 Laboratory Contaminants

Field blank and trip blank samples provide an indication of non-site related contamination that could be introduced into a sample set during the collection, transportation, preparation, or analysis of samples. To remove non-site related constituents from further consideration, the concentrations of chemicals detected in blanks were compared with concentrations of the same chemicals detected in the environmental samples.

Common laboratory contaminants (i.e., acetone, 2-butanone, chloroform, methylene chloride, toluene, and phthalate esters) were retained for use in interpreting site conditions only when observed concentrations in any environmental sample exceeded ten times the maximum concentration detected in any blank. If the concentration of a common laboratory contaminant was less than ten times the maximum blank concentration, its presence among the sample set was attributed to laboratory contamination in that particular sample and excluded from further evaluation (USEPA, 1989). The maximum concentrations of detected common laboratory contaminants in blanks were as follows:

- Acetone 36 J µg/L
- Methylene chloride 13 J µg/L
- 2-Butanone 49 J µg/L
- bis-(2-Ethylhexyl)phthalate 56 J µg/L

A limited number of environmental samples that exhibited high concentrations of tentatively identified compounds (TICs) were subjected to an additional sample preparation. Medium level sample preparation provides a corrected Contract Required Quantitation Limit (CRQL) based on the volume of sample used for analysis. The corrected CRQL produces higher detection limits than the low level sample preparation. A comparison to laboratory blanks used in the medium level preparation was used to evaluate the relative amount of contamination within these samples.

4.2.2 Naturally-Occurring Inorganic Analytes

In order to differentiate between inorganic contamination due to site operations and naturally-occurring inorganic analytes in site media, results of the sample analyses were compared to information regarding background conditions at MCB, Camp Lejeune. Appendix M presents base-specific background information pertaining to each of the sampling media addressed in this RI. The following items were used to evaluate each media:

Soil:	MCB, Camp Lejeune Background Soil Evaluation Report
Groundwater:	MCB, Camp Lejeune Background Groundwater Evaluation Report
Surface Water:	MCB, Camp Lejeune Background Surface Water Analytical Results
Sediment:	MCB, Camp Lejeune Background Sediment Analytical Results

The subsections which follow address the various comparison criteria used to evaluate soil, groundwater, surface water, and sediment analytical results from samples collected at Site 63.

4.2.2.1 Soil

In general, comparison criteria or screening standards are not available for specific compounds and analytes in soil. As a result, base-specific background concentrations have been compiled from a number of locations throughout MCB, Camp Lejeune to evaluate reference levels of inorganic analytes in surface and subsurface soils.

Typical background concentration values for inorganic analytes in soils at MCB, Camp Lejeune are presented as an evaluation report within Appendix M. The evaluation report describes the various soil types from which background samples were collected and also the range of inorganic concentrations detected. These concentration ranges are based on analytical results of background samples collected in areas not known to have been impacted by operations or disposal activities adjacent to Sites 1, 2, 6, 7, 16, 28, 30, 35, 36, 41, 43, 44, 54, 69, 73, 74, 78, 80, and 86 (refer to Figure 1-2 for site locations throughout MCB, Camp Lejeune). Subsequent discussions of the analytical results from samples collected during the soil investigation only consider those inorganic analytes with concentrations exceeding twice the average base-specific background concentration, as recommended by USEPA Region IV (USEPA, 1991b).

In general, background soil samples have been collected outside the known boundaries of those sites listed above, in areas with similar soil types. As provided in Appendix M, the greatest portion of MCB, Camp Lejeune is underlain by a number of similar soil units. Soils found on this portion of the coastal plain are moderately to strongly acidic in nature and are classified under the USCS as SM, SM-SP (i.e., fine sand or loamy fine sand).

4.2.2.2 Groundwater

Chemical-specific standards are available for evaluation of analytical results from groundwater samples. In subsequent sections which address the analytical results of samples collected during the groundwater investigation, only those inorganic parameters with concentrations exceeding applicable state or federal regulations will be discussed.

Higher concentrations of certain metals in unfiltered groundwater samples collected at MCB, Camp Lejeune are not considered atypical based on experience gained during other studies. An evaluation report which pertains to naturally occurring inorganics in groundwater at MCB, Camp Lejeune is provided in Appendix M. USEPA Region IV requires that unfiltered inorganic concentrations be used to assess site conditions and evaluate risks to human health and the environment. In the subsections which follow only total (i.e., unfiltered) TAL metal analytical results from groundwater will be presented and discussed.

4.2.2.3 Surface Water

In the sections which address the analytical results of samples collected during the surface water investigation, only those inorganic parameters with concentrations exceeding applicable state or federal regulatory limits will be discussed. Base-specific background concentrations have been compiled from a number of locations throughout MCB, Camp Lejeune to supplement the evaluation of detected inorganic analytes in surface water. Typical inorganic background concentration values for surface waters at MCB, Camp Lejeune are presented in Appendix M. These values are based on analytical results of background samples collected upgradient of areas known or suspected to have been impacted by operations or disposal activities.

4.2.2.4 Sediment

Base-specific inorganic background concentrations in sediment have been compiled from a number of locations throughout MCB, Camp Lejeune to supplement the evaluation of detected inorganic analytes in sediment. Those inorganic analytes that exceed applicable state or federal regulatory limits are compared to base-specific background concentrations in subsequent sections. Typical inorganic background concentration values for sediments at MCB, Camp Lejeune are presented in Appendix M. These comparison values are based on analytical results of background samples collected upgradient of areas known or suspected to have been impacted by operations or disposal activities.

4.3 Analytical Results

This section presents analytical results from the soil, groundwater, surface water, and sediment investigations performed at Site 63. A summary of site contamination, by media, is provided in Table 4-1.

4.3.1 Soil Investigation

Unique sample notations were employed to identify soil samples and sample depths at Site 63. Soil samples designated with the prefix "TW" were collected from temporary monitoring well pilot test borings. The "SB" designation was used to denote samples collected from soil test borings. The following suffix designations refer to the depth at which a sample was obtained:

00 - ground surface to 12 inches below ground surface (i.e., surface soil)
01 -1 to 3 feet below ground surface
02 -3 to 5 feet below ground surface
03 - 5 to 7 feet below ground surface
04 - 7 to 9 feet below ground surface
05 - 9 to 11 feet below ground surface

Surface soil positive detection summaries for organic compounds and inorganic analytes are presented in Tables 4-2 and 4-3. A positive detection summary of organic compounds in subsurface soil is presented in Table 4-4; a summary of inorganic analytes is provided in Table 4-5. Soil samples collected at Site 63 were analyzed for full TCL organics and TAL inorganics using CLP protocols and Level IV data quality (refer to Section 3.0). Soil samples obtained from temporary monitoring well test borings were also analyzed for full TCL organics and TAL inorganics.

4.3.1.1 Surface Soil

A total of 46 surface soil samples were obtained at Site 63 and submitted for TCL organic and TAL inorganic analyses. As indicated in Table 4-1, volatile organic compounds were not detected among any of the surface samples obtained at Site 63.

Three semivolatile compounds were detected in 2 of the 46 surface soil samples that were submitted for laboratory analyses. N-nitrosodiphenylamine and di-n-butylphthalate were each detected once at estimated concentrations of 51 J and 78 J µg/kg, respectively. Although bis(2-ethylhexyl)-phthalate (BEHP) was identified in a total of seven samples, only once was it detected at a level that exceeded ten times the maximum blank concentration. As previously discussed, if the concentration of a common laboratory contaminant was less than ten times the maximum blank concentration its presence among the sample set was attributed to laboratory contamination and excluded from further evaluation. Each of the three positive SVOC detections were observed in soil samples obtained from within or immediately adjacent to the suspected disposal portion of the study area. As presented in Table 4-1, semivolatile concentrations ranged from 51 J of n-nitrosodiphenylamine to 4,400 µg/kg of BEHP. None of the SVOCs were detected at concentrations exceeding USEPA Region III Soil Screening Levels for Protection of Groundwater (USEPA, 1994).

Pesticide compounds were detected in a total of 17 of the 46 surface soil samples submitted for laboratory analyses from Site 63. Unlike SVOC detections, pesticides were widely scattered at low concentrations throughout the suspected disposal portion of the study area. As indicated in Table 4-1, the compounds 4,4'-DDT, 4,4'-DDE, endosulfan sulfate, and dieldrin, in decreasing order of frequency, were the most prevalent of the seven pesticides detected. 4,4'-DDT and 4,4'-DDE were detected in 7 and 11 of the surface soil samples, respectively. 4,4'-DDD, alpha-chlordane, and gamma-chlordane were each detected only twice among the surface samples. The compounds 4,4'-DDE, 4,4'-DDT, alpha-chlordane, and gamma-chlordane were detected at their respective maximum concentrations in a sample obtained from location 63-SB35, which lies adjacent to the unnamed tributary. Pesticide concentrations ranged from 1.9 J µg/kg of endosulfan sulfate to 55 J µg/kg of 4,4'-DDE.

Two surface samples, both obtained within the suspected disposal portion of the study area, had one positive detection of a PCB compound. Aroclor-1260 was detected at concentrations of 28 J and 97 µg/kg in samples 63-SB21 and 63-SB30, respectively. No other PCB compounds were detected among any of the 46 surface samples obtained from Site 63.

Twenty-two of 23 TAL metals were detected among the 46 surface soil samples obtained from Site 63 (thallium was not detected). Table 4-1 provides a summary of barium, iron, manganese, and all priority pollutant metals found within soil samples. Priority pollutant metals are a subset of TAL metals that include antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc. As provided in Table 4-1, arsenic, barium, chromium, copper, iron, lead, manganese, silver, and zinc were each detected at concentrations exceeding twice their average base-specific (i.e., MCB, Camp Lejeune) background levels (refer to Table 4-1 and Appendix M for base-specific inorganic background concentrations) within at least five of the surface soil samples. Copper, manganese, and zinc were detected at concentrations greater than one order of magnitude above twice their average base-specific background levels in samples obtained from the central portion of the suspected disposal area. In addition, barium was detected in three surface soil samples at concentrations which exceeded the soil screening value of 32 mg/kg. The maximum barium concentration, 53.1 mg/kg, was detected in a sample obtained from test boring 63-SB35, located adjacent to the unnamed tributary.

4.3.1.2 Subsurface Soil

A total of 50 subsurface (i.e., greater than one-foot below ground surface) soil samples were obtained at Site 63 and submitted for TCL organic and TAL metal analyses. As indicated in Table 4-1, no PCB compounds were detected among the 50 subsurface samples.

Styrene was the only VOC detected among the subsurface samples submitted for analyses from Site 63. As provided in Table 4-1, styrene was detected once among the 50 subsurface samples at a concentration of 41 µg/kg. The positive styrene detection was found in a sample obtained adjacent to the suspected disposal area.

Semivolatile compounds were detected in only 4 of the 50 subsurface soil samples obtained from Site 63 (refer to Table 4-1). Two semivolatile compounds were detected among the subsurface samples, n-nitrosodiphenylamine and BEHP. Three detections of BEHP were observed at levels exceeding ten times the maximum blank concentration of 560 µg/kg. Concentrations of the three BEHP detections ranged from 770 to 4,700 µg/kg. N-nitrosodiphenylamine was detected twice among the 50 subsurface samples at estimated concentrations of 94 J and 350 J µg/kg. Each of the positive SVOC detections was observed in samples obtained from within or adjacent to the suspected disposal portion of the study area.

Four pesticide compounds were detected among the 50 subsurface soil samples obtained from Site 63. As presented in Table 4-1, the pesticides dieldrin, 4,4'-DDE, 4,4'-DDD, and 4,4'-DDT were detected in samples obtained from within or adjacent to the suspected disposal portion of the study area. Pesticide concentrations among subsurface samples ranged from 2.1 J µg/kg of dieldrin to 7.8 µg/kg of 4,4'-DDT. Pesticides were detected in only 4 of the 50 subsurface soil samples.

Twenty-one of the 23 TAL metals were detected among the 50 subsurface soils collected at Site 63 (cadmium and mercury were not detected). Table 4-1 provides a summary of barium, iron, manganese, and all priority pollutant metals detected within soil samples from Site 63. As presented in Table 4-1, aluminum, arsenic, chromium, copper, iron, lead, manganese, nickel, and zinc were each detected at concentrations exceeding twice their average base-specific background levels (refer to Appendix M) within at least ten of the subsurface soil samples. Barium, iron, lead, manganese, nickel, and zinc were each detected at concentrations greater than one order of magnitude above twice their average base-specific background levels. Additionally, arsenic, barium, and nickel were detected at concentrations which exceeded soil screening values protective of groundwater among one, two, and seven of the subsurface samples, respectively. As provided in Table 4-1, the maximum concentrations of arsenic, barium, and nickel were 16, 1,120, and 76.1 mg/kg. The soil screening values protective of groundwater for arsenic, barium, and nickel are 15, 32, and 21 mg/kg.

4.3.1.3 Summary

A positive detection of one VOC was observed among the 96 soil samples obtained from Site 63. The VOC styrene was detected at a concentration of 41 µg/kg in sample 63-SB15, located immediately adjacent to the suspected disposal portion of the study area.

Positive detections of SVOCs among both surface and subsurface samples obtained at Site 63 were primarily limited to within or immediately adjacent to the suspected disposal portion of the study area. Three different semivolatiles were identified during the soil investigation, as presented in Table 4-1.

Based upon the results of analyses from 46 surface and 50 subsurface soil samples, the pesticides 4,4'-DDE and 4,4'-DDT appear to be scattered throughout the suspected disposal portion of the study area. 4,4'-DDT was the most prevalent, with 12 positive detections ranging from 2 to 50 J µg/kg. The highest pesticide concentration was that of 4,4'-DDE at 55 J µg/kg.

Inorganic analytes were detected in both surface and subsurface soil samples throughout the study area. Several TAL metals were detected above twice their average base-specific background levels among the 96 soil samples. Concentrations of arsenic, barium, and nickel exceeded applicable soil screening levels in one, five, and seven samples, respectively. In general, no discernible pattern of inorganic analytes was evident among soil samples obtained from the study area. Section 4.4.1 describes the occurrence and distribution of inorganic analytes in soil at Site 63.

4.3.2 Groundwater Investigation

The groundwater investigation at Site 63 entailed the collection of samples from three existing shallow wells (63-GW01, 63-GW02, and 63-GW03) and eight temporary wells (63-TW01 through 63-TW08). Each of the groundwater samples collected at Site 63 was analyzed for full TCL organics and TAL total metals using CLP protocols and Level IV data quality. Analytical results from the groundwater investigation at Site 63 are provided in the paragraphs which follow. A positive detection summary of organic compounds is provided in Table 4-6; total metal results are presented in Table 4-7.

Groundwater conditions within the upper portion of the surficial aquifer were evaluated through collection and analysis of samples from existing shallow and newly installed temporary monitoring wells at Site 63 (refer to Section 3.0 and Appendix B for well construction details). A total of 11 shallow groundwater samples from Site 63 were submitted for laboratory analyses. As indicated in Table 4-1, no organic compounds were detected among the 11 groundwater samples collected from the surficial aquifer; therefore, organic analytical results will not be addressed.

TAL total metals were detected in each of the temporary and shallow monitoring wells at Site 63. A complete positive detection summary for total metals in groundwater is provided in Table 4-7. In all, 13 of the 23 TAL total metals were detected within at least one groundwater sample at Site 63 (antimony, beryllium, cadmium, chromium, copper, mercury, selenium, silver, thallium, and vanadium were not detected among shallow groundwater samples). As provided in Table 4-1, iron, manganese, and zinc were the only TAL metals detected at concentrations in excess of state or federal screening standards. Iron exceeded the NCWQS of 300 μg/L among 4 of the 11 shallow groundwater samples, with a maximum concentration of 24,300 μg/L. Manganese was detected at concentrations exceeding the NCWQS of 50 μg/L in 4 of the 11 shallow groundwater samples, with a maximum concentration of 311 μg/L. Lastly, zinc was detected in sample 63-TW07 at a concentration of 17,100 μg/L which exceeded the NCWQS level of 2,100 μg/L.

4.3.3 Surface Water Investigation

Environmental samples were collected from an unnamed tributary to Mill Run as part of the surface water investigation at Site 63; the unnamed tributary borders the eastern portion of the study area. A total of five surface water samples were collected at Site 63 during the field investigation. Each of the five surface water samples was analyzed for full TCL organics and TAL inorganics using CLP protocols and Level IV data quality.

Analytical results from the surface water investigation at Site 63 are presented in the paragraphs which follow. Table 4-1 provides a summary of analytical results from the surface water investigation. Positive detection summaries of both organic compounds and inorganic analytes found among surface water samples are provided in Tables 4-8 and 4-9. National Oceanic and Atmospheric Administration (NOAA) screening values and North Carolina WQS were employed during the evaluation of surface water analytical results. No organic compounds were detected among any of the five surface water samples submitted for those analyses; therefore, those results will not be considered further.

As presented in Table 4-9, 12 of the 23 TAL total metals were positively identified among the surface water samples obtained at Site 63 (antimony, beryllium, cadmium, chromium, cobalt, mercury, nickel, selenium, silver, thallium, and zinc were not detected). Positive detections of metals were compared to screening values for surface water bodies classified as fresh (i.e., having less than five percent salt content). Aluminum was the only TAL total metal detected among surface water samples at concentrations which exceeded applicable screening values. Aluminum was detected in each of the five surface water samples at concentrations which ranged from 602 to 688 µg/L. The North Carolina screening value for aluminum in Class "SC" Nutrient Sensitive surface water bodies is 87 µg/L. Although positive aluminum detections exceeded the appropriate screening value, they did not exceed the range of base-specific background concentrations (refer to Appendix M). No other total metal concentrations among surface water samples exceeded state or federal screening values.

4.3.4 Sediment Investigation

Sediment samples were collected from the unnamed tributary to Mill Run as part of the investigation at Site 63. A total of five sediment samples were collected during the investigation; one sample was collected from each of the five sampling stations. Sediment samples were obtained from zero to six inches into the sediment. Each of the five sediment samples was analyzed for full TCL organics and TAL inorganics using CLP protocols and Level IV data quality. In addition, each of the sediment samples was submitted for grain size and total organic carbon analyses.

Analytical results from the sediment investigation at Site 63 are provided in the paragraphs which follow. Table 4-1 provides a summary of sediment contamination. Positive detection summaries of organic compounds found in the unnamed tributary are provided in Table 4-10. Total metal results from sediment samples obtained as part of the Site 63 investigation are presented in Table 4-11. Volatile, semivolatile, and PCB compounds were not detected in any of five sediment samples and, therefore, will not be addressed.

The pesticide 4,4'-DDD was detected in two of the five sediment samples obtained from the unnamed tributary. As indicated in Table 4-10, the pesticides 4,4'-DDE, 4,4'-DDT, alpha-chlordane, and gamma-chlordane were each detected only once among the five sediment samples. The maximum pesticide concentration, 4,4'-DDD at 11 J µg/kg, was detected in a sample obtained from station 63-SD04. As indicated in Table 4-1, each positive detection of the five identified pesticides exceeded applicable screening values. The pesticides 4,4'-DDE, 4,4'-DDT, alpha-chlordane, and gamma-chlordane were detected at estimated maximum concentrations of 4.2 J, 1.6 J, 4.7 J, and 6.2 J µg/kg, respectively. No other pesticide compounds were detected among sediment samples obtained from the unnamed tributary.

Sixteen of the 23 TAL total metals were positively identified among the five sediment samples (antimony, cadmium, cobalt, mercury, selenium, silver, and thallium were not detected). As indicated in Table 4-1, none of the TAL metals were identified at concentrations in excess of their respective NOAA Effects Range Low (ER-L) screening values. Inorganic analytical results from the five sediment samples obtained at Site 63 are provided in Table 4-11.

4.4 Extent of Contamination

This section addresses the extent of contamination within soil, groundwater, surface water, and sediment at Site 63.

4.4.1 Extent of Soil Contamination

Positive detections of organic compounds in both surface and subsurface soil samples at Site 63 are depicted on Figures 4-1 and 4-2. Figures 4-3 and 4-4 present selected TAL metal sampling results which were detected above base-specific background levels and contributed to human health risk (refer to Section 6.0). The following subsections detail the presence of both organic compounds and inorganic analytes among soil samples at Site 63.

4.4.1.1 Volatiles

Styrene was detected in only one of the subsurface soil samples obtained at Site 63. As depicted in Figure 4-2, styrene was detected at a concentration of 41 µg/kg in a subsurface sample from location 63-SB15. No other VOCs were detected among the 96 soil samples retained for laboratory analyses. Given the limited extent of styrene and the lack corroborating evidence of volatile contamination, the presence of styrene is most likely the result of a single event rather than long-term disposal operations. Additionally, the single styrene detection did not exceed the applicable soil screening value of 2,000 µg/kg.

4.4.1.2 Semivolatiles

The presence of SVOCs in soil is most likely the result of former operational activities at Site 63. The low concentration and infrequent detection of semivolatile compounds among soil samples is consistent with the historical use of Site 63 and is most likely the result of incidental maneuvers and training exercises. Semivolatile compounds were identified in both surface and subsurface soil samples obtained from the suspected disposal portion of the study area. As depicted in Figures 4-1 and 4-2, concentrations of SVOCs were limited to two surface and three subsurface sampling locations throughout the entire site. The positive SVOC results correspond directly to the visual identification of graded soil or construction debris observed during the field investigation (refer to Appendices A and B for soil descriptions). None of the positive SVOC detections exceeded applicable soil screening values for the protection of groundwater, nor do they suggest long-term disposal operations. The presence of SVOCs in soil does suggest that vehicles or mechanized equipment may have been used at the site.

4.4.1.3 Pesticides

Positive detections of pesticides were observed in both surface and subsurface soil samples at Site 63. As Figures 4-1 and 4-2 depict, pesticide concentrations were low (i.e., less than 0.1 µg/kg) and primarily limited to within and adjacent to the suspected disposal portion of the study area. The majority of pesticide detections were observed in surface soil samples. The frequency and overall concentration of pesticides in soil, nonetheless, does not suggest pesticide disposal activities. Much of the study area appears to have been graded during previous site operations (refer to Section 2.0); the reworked surface soil may have contained residual pesticides. The presence of pesticide compounds among soil samples obtained at Site 63 is most likely the result of routine application and use of pesticides.

4.4.1.4 Metals

As addressed in Section 4.3.1 and provided in Table 4-1, a number of samples submitted for analyses had TAL metal concentrations which exceeded applicable soil screening values or base-specific background levels. Arsenic, barium, and nickel were detected at concentrations which exceeded USEPA Region III soil screening values protective of groundwater among one, five, and seven of the 96 soil samples submitted for analyses; however, the same three inorganic analytes were not detected above NCWQS levels among any of the groundwater samples obtained at Site 63. Figures 4-3 and 4-4 provide the sampling locations where arsenic, barium, and nickel were detected in excess of soil screening values. Additionally, Figures 4-3 and 4-4 depict the distribution and concentrations of selected TAL metals which were detected in excess of base-specific background levels (refer to Table 4-1) and contributed to health-based risk indices (see Section 6.0); the figures characterize the distribution of inorganic analytes considered to be of potential concern to human health and the environment. The limits of surface and subsurface debris, as presented on Figures 4-3 and 4-4, were determined through visual observation of concrete, metal, and wood.

In general, the distribution of detected inorganic analytes among both surface and subsurface samples followed no discernible pattern. In at least one case, however, findings from the analytical program were consistent with visual observations of buried debris and non-native surface material recorded during the field investigation (refer to Appendices A and B). A total of 13 inorganics were detected above twice their average base-specific background levels; 9 of the 13 analytes were detected at maximum concentrations in a subsurface sample obtained from location 63-SB23. As depicted in Figure 4-4, boring 63-SB23 is located within the central portion of the suspected disposal area where surface and subsurface debris were identified. With the exception of boring 63-SB23, inorganic analytes were observed at varying concentrations throughout the study area.

4.4.2 Extent of Groundwater Contamination

Figure 4-5 presents groundwater sampling results of TAL total metals detected at concentrations in excess of either federal MCLs or North Carolina WQS standards. As addressed in Section 4.3.2, volatile, semivolatile, pesticide, and PCB organic compounds were not detected in any of the groundwater samples submitted for analyses from Site 63. As a result of those analyses, the extent of organic compounds in groundwater will not be addressed.

4.4.2.1 Metals

Inorganic analytes were detected in each of the 11 groundwater samples submitted for analyses from Site 63. Iron, manganese, and zinc were the only TAL total metals detected at levels in excess of either federal MCLs or North Carolina WQS (refer to Figure 4-5). Positive detections that exceeded applicable screening standards for both iron and manganese were distributed throughout the suspected disposal portion of the study area. The sample obtained from temporary well 63-TW07 exhibited the only positive detection of zinc that exceeded the 2,100 μg/L screening standard; zinc was detected at a concentration of 17,100 μg/L. Subsurface soil samples collected from both the eastern and western portions of the study area had positive detections of zinc which exceeded background levels (refer to Figure 4-4). Although the distribution of zinc among soil samples is not limited to the suspected disposal portion of the study area, temporary well 63-TW07 is located within one of the areas identified as having elevated concentrations of zinc in soil. The presence of zinc in soil does not completely account for its elevated concentration in groundwater, however. One would expect that if zinc disposal operations had taken place at Site 63 elevated concentrations of zinc would also be evident in the adjacent monitoring well 63-GW02 and at much higher concentrations among soil samples obtained from the suspected disposal area. Temporary monitoring well 63-TW07 is hydraulically downgradient from the suspected disposal portion of the study area and permanent well 63-GW02. The limited dispersion of zinc in sampling media suggests that its presence is not indicative of former or ongoing disposal activities. Furthermore, zinc has not been detected at significant concentrations in the adjacent stream; a downgradient groundwater receptor.

Groundwater within the coastal plain region of North Carolina is naturally rich in iron and manganese. Groundwater concentrations of both iron and manganese at MCB, Camp Lejeune often exceed the state standards of 300 and 50 µg/L. Elevated levels of iron and manganese, at concentrations above the NCWQS, were reported in samples collected from a number of base potable water supply wells which were installed at depths greater than 162 feet below ground surface (Greenhorne and O'Mara, 1992). The draft report entitled "Evaluation of Metals in Groundwater at MCB, Camp Lejeune, North Carolina," (provided in Appendix M) addresses the pervasiveness of total metals in groundwater and identifies a number of potential causes. Preliminary conclusions of the study support the theory that certain total metal concentrations in groundwater are due more to geologic conditions (i.e., naturally occurring concentrations and unconsolidated soils) and sample acquisition methods than to mobile metal concentrations in the surficial aquifer.

Iron and manganese concentrations from a number of wells at Site 63 exceeded the NCWQS but fell within the range of concentrations for samples collected elsewhere at MCB, Camp Lejeune. Additionally, positive detections of both iron and manganese among groundwater samples retained from the upper-most portion of the surficial aquifer had no discernible pattern of distribution. The presence and concentrations of both iron and manganese in groundwater samples obtained at Site 63 appear to be indicative of natural site conditions rather than disposal activities.

4.4.3 Extent of Surface Water Contamination

Figure 4-6 presents TAL metal sampling results in excess of either state or federal surface water screening values. A summary of site contamination is presented in Table 4-1. As addressed in Section 4.3.3, no organic compounds were detected among any of the five surface water samples submitted for analyses from Site 63. As a result of those analyses, the extent of organic compounds in surface water will not be addressed.

4.4.3.1 Metals

Aluminum was the only TAL total metal identified among each of the five surface water samples obtained from the unnamed tributary that exceeded state or federal chronic screening values. As depicted in Figure 4-6, each sampling station had a positive detection of aluminum above the 87 µg/L screening value. Positive aluminum detections among the five surface water samples obtained from the unnamed tributary ranged from 602 to 688 µg/L. The headwaters of the unnamed tributary are less than one hundred yards upgradient of Site 63, amongst pine and hardwood trees. The combination of acidic soil and acidification from decaying leaves and pine needles most probably has contributed to the slightly acidic nature of surface water at Site 63. Field chemistry results suggest that the pH of the unnamed tributary is less than 4.0 (refer to Table 3-9). Several hundred or even several thousand milligrams per liter of aluminum is not unusual for natural waters having a pH below 4.0 (USGS, 1992). The slight acidity of surface water at Site 63, coupled with the natural occurrence of aluminum in site soil and sediment has effectively contributed to the observed levels of aluminum among each of the surface water samples.

4.4.4 Extent of Sediment Contamination

Positive detections of organic compounds in sediment samples collected at Site 63 are depicted on Figure 4-7. None of the TAL metal sampling results from Site 63 exceeded NOAA ER-L chronic sediment screening values; therefore, the extent of inorganic analytes in sediment will not be addressed. A summary of site contamination is presented in Table 4-1. As addressed in Section 4.3.4 volatile, semivolatile, and PCB compounds were not detected among any of the five sediment samples submitted for analyses from Site 63. As a result of those analyses the extent of volatile, semivolatile, and PCB compounds in sediment will not be addressed.

4.4.4.1 Pesticides

The pesticides 4,4'-DDE, 4,4'-DDD, 4,4'-DDT, alpha-chlordane, and gamma-chlordane were detected in one of the five sediment samples retained for analysis from Site 63. The only other pesticide detection was that of 4,4'-DDD in a sample obtained from a separate station. As depicted on Figure 4-7, each of the pesticides were detected at concentrations less than 15 µg/kg. The maximum pesticide concentration among the five sediment samples obtained for laboratory analysis was 11J µg/kg of 4,4'-DDD. Each of the pesticide detections exceeded applicable NOAA ER-L chronic sediment screening values. The observed concentrations of the detected pesticides were typical of levels observed in sediments throughout MCB, Camp Lejeune. Positive detections of these compounds at Site 63 are most likely the result of former base-wide application and use of pesticides. The frequency and overall concentration of pesticides at Site 63 is not indicative of pesticide disposal activities.

4.5 References

Baker Environmental, Inc. September 1995. Remedial Investigation/Feasibility Study Work Plan for Operable Unit No.13 (Site 63), Marine Corps Base Camp Lejeune, North Carolina. Final. Prepared for the Department of the Navy, Naval Facilities Engineering Command, Atlantic Division, Norfolk, Virginia.

Greenhorne & O'Mara, Inc. 1992. Wellhead Monitoring Study Marine Corps Base, Camp Lejeune, North Carolina. Preliminary Draft. Prepared for Department of the Navy, Naval Facilities Engineering Command, Atlantic Division, Norfolk, Virginia.

United States Environmental Protection Agency (USEPA). 1988. Laboratory Guidelines for Evaluating Inorganics Analyses. Prepared for: Hazardous Site Evaluation Division, U.S. Environmental Protection Agency. Compiled by: Ruth Bleyler. Prepared by: The USEPA Data Review Work Group.

USEPA. 1989. Risk Assessment Guidance for Superfund Volume II. Environmental Evaluation Manual Interim Final. Office of Solid Waste and Emergency Response. Washington, D.C. EPA/540/1-89-001. May 1989.

USEPA. 1991a. National Functional Guidelines for Organic Data Review. Draft. USEPA Contract Laboratory Program.

USEPA. 1991b. Supplemental Region IV Risk Assessment Guidance for Superfund. Prepared by Region IV risk assessment staff to supplement and clarify the Risk Assessment Guidance for Superfund (RAGS) manual. March 26, 1991.

USEPA. 1994. USEPA Region III Risk-Based Concentrations. Compiled by: R.L. Smith. Soil Screening Levels for Protection of Groundwater.

U.S. Geological Survey (USGS). 1992. Study and Interpretation of the Chemical Characteristics of Natural Water. Third Edition. Prepared by John D. Hem for the U.S. Department of the Interior.

SECTION 4.0 TABLES

TABLE 4-1

SUMMARY OF SITE CONTAMINATION
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction (units)	Detected Contaminants or Analytes	Comparison Criteria		Min.	Max.	Location of Maximum Detection	Detection Frequency	Detections Above		Distribution of Positive Detections
			Screening Standard	Base Background					Screening Standard	Base Background	
Surface Soil	Volatile (µg/kg)	ND	Soil SL	NA				0/46			
	Semivolatile (µg/kg)	Nitrosodiphenylamine	200	NA	51 J	51 J	SB12	1/45	0/45	NA	adjacent to 63-GW01
		Di-n-butylphthalate	120,000	NA	78 J	78 J	63-TW06	1/45	0/45	NA	southeast
		BEHP	11,000	NA	41 J	4,400	SB12	7/45	0/45	NA	1 exceeds blank conc.
	Pesticide (µg/kg)	Dieldrin	1.0	NA	3 J	4.1 J	SB32	3/46	3/46	NA	central, scattered
		4-4'-DDE	500	NA	2.7 J	55 J	SB35	7/45	0/45	NA	central, scattered
		4-4'-DDD	700	NA	12	26 J	SB35	2/45	0/45	NA	central and eastern
		Endosulfan Sulfate	NA	NA	1.9 J	2.8 J	SB18	4/45	NA	NA	central and northern
		4-4'-DDT	1,000	NA	2 J	50 J	SB29	11/45	0/45	NA	central, scattered
		alpha-Chlordane	NA	NA	3.5	16	SB35	2/45	NA	NA	central and eastern
		gamma-Chlordane	NA	NA	2.7 J	9	SB35	2/45	NA	NA	central and eastern
	PCB (µg/kg)	Aroclor-1260	NA	NA	28 J	97	SB30	2/45	NA	NA	central
	Metal (1) (mg/kg)	Arsenic	15	1.3	0.32	3.7	SB21	36/46	0/46	5/46	scattered
		Barium	32	17.3	3.0	53.1	SB35	46/46	3/46	8/46	scattered
		Beryllium	180	0.2	0.1 J	0.27	SB32	5/46	0/46	1/46	central
		Cadmium	6	0.7	1.0	3.1	SB21	2/46	0/46	2/46	central and eastern
		Chromium	NA	6.6	1.1	11.1	SB21	44/46	NA	6/46	scattered
		Copper	NA	7.1	0.47	74.8	SB29	29/46	NA	10/46	scattered
		Iron	NA	3,702	590	22,400	SB21	46/46	NA	9/46	scattered
		Lead	NA	23.4	2.6	107	SB29	46/46	NA	5/46	scattered
		Manganese	NA	18.5	3.4 J	348 J	SB03	46/46	NA	13/46	scattered
		Mercury	3	0.09	0.06	0.21 J	SB23	4/46	0/46	1/46	central
		Nickel	21	3.5	0.62 J	9.8	SB21	33/46	0/46	2/46	central
		Silver	NA	0.9	0.72	0.97	SB29	2/46	NA	1/46	central
		Zinc	42,000	13.8	0.98	1,860	SB21	36/46	0/46	7/46	scattered

TABLE 4-1 (Continued)

SUMMARY OF SITE CONTAMINATION
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction (units)	Detected Contaminants or Analytes	Comparison Criteria: Screening Standard	Comparison Criteria: Base Background	Min.	Max.	Location of Maximum Detection	Detection Frequency	Detections Above: Screening Standard	Detections Above: Base Background	Distribution of Positive Detections
Subsurface	Volatile (µg/kg)	Styrene	2,000	NA	41	41	SB15	1/50	0/50	NA	northwest
Soil	Semivolatile (µg/kg)	Nitrosodiphenylamine	200	NA	94 J	350 J	SB19	2/49	1/49	NA	northern
		BEHP	11,000	NA	41 J	4,700	SB19	12/49	0/49	NA	3 exceed blank conc.
	Pesticide (µg/kg)	Dieldrin	1.0	NA	2.1 J	5.0 J	SB32	2/50	2/50	NA	northern and western
		4,4'-DDE	500	NA	2.6 J	2.8 J	SB22	2/50	0/50	NA	central
		4,4'-DDD	700	NA	5.6	5.6	SB22	1/50	0/50	NA	central
		4,4'-DDT	1,000	NA	7.8	7.8	SB20	1/50	0/50	NA	northern
	PCB (µg/kg)	ND	Soil SL	NA				0/50			
	Metal (1) (mg/kg)	Aluminum	NA	7,413	312	16,000	SB07	50/50	NA	32/50	scattered
		Antimony	NA	6.5	2.5 J	16.2 J	SB23	7/42	NA	1/42	central
		Arsenic	15	2	0.4	16	SB14	47/50	1/50	28/50	scattered
		Barium	32	14.4	2.5	1,120	SB23	50/50	2/50	8/50	scattered
		Beryllium	180	0.2	0.08	0.29	63-TW08	18/50	0/50	6/50	scattered
		Chromium	NA	12.5	1.2	84.4	SB23	50/50	NA	27/50	scattered
		Copper	NA	2.4	0.55	160	SB23	38/50	NA	27/50	scattered
		Iron	NA	7,135	425 J	149,000	SB23	50/50	NA	20/50	scattered
		Lead	NA	8.3	2 J	1,650	SB23	50/50	NA	11/50	scattered
		Manganese	NA	8.0	1.5	586	SB23	50/50	NA	18/50	scattered
		Nickel	21	3.7	1.0	76.1	SB26	44/50	7/50	19/50	scattered
		Silver	NA	0.9	1.8	5.3	SB23	2/50	NA	2/50	central
		Zinc	42,000	6.7	1.3	1,130	SB23	38/50	0/50	16/50	scattered
Groundwater	Volatile (µg/L)	ND	NCWQS/ MCL	NA				0/11			
	Semivolatile (µg/L)	ND	NCWQS/ MCL	NA				0/11			
	Pesticide (µg/L)	ND	NCWQS/ MCL	NA				0/10			
	PCB (µg/L)	ND	NCWQS/ MCL	NA				0/10			
	Total Metal (µg/L)	Iron	300	NA	73.5	24,300	63-TW05	8/11	4/11	NA	central
		Manganese	50	NA	1.8	311	63-GW02	11/11	4/11	NA	central
		Zinc	2,100	NA	4.9	17,100	63-TW07	6/11	1/11	NA	eastern

TABLE 4-1 (Continued)

SUMMARY OF SITE CONTAMINATION
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction (units)	Detected Contaminants or Analytes	Comparison Criteria		Min.	Max.	Location of Maximum Detection	Detection Frequency	Detections Above		Distribution of Positive Detections
			Screening Standard	Base Background					Screening Standard	Base Background	
Surface Water	Volatile (µg/L)	ND	NCWQS	NA				0/5			
	Semivolatile (µg/L)	ND	NCWQS	NA				0/5			
	Pesticide (µg/L)	ND	NCWQS	NA				0/5			
	PCB (µg/L)	ND	NCWQS	NA				0/5			
	Metal (2) (µg/L)	Aluminum	87	1,350	602	688	63-SW05	5/5	5/5	0/5	maximum downstream
Sediment	Volatile (µg/kg)	ND	NOAA ER-L	NA				0/5			
	Semivolatile (µg/kg)	ND	NOAA ER-L	NA				0/5			
	Pesticide (µg/kg)	4,4'-DDE	2	NA	4.2 J	4.2 J	63-SD04	1/5	1/5	NA	adjacent to site
		4,4'-DDD	2	NA	2.6 J	11 J	63-SD04	2/5	2/5	NA	adjacent to site
		4,4'-DDT	1	NA	1.6 J	1.6 J	63-SD04	1/5	1/5	NA	adjacent to site
		alpha-Chlordane	0.5	NA	4.7 J	4.7 J	63-SD04	1/5	1/5	NA	adjacent to site
		gamma-Chlordane	0.5	NA	6.2 J	6.2 J	63-SD04	1/5	1/5	NA	adjacent to site
	PCB (µg/kg)	ND	NOAA ER-L	NA				0/5			
	Metal (2) (mg/kg)	ND above screening val	NOAA ER-L	Background					0/5	0/5	

Notes: - Concentrations are presented in µg/L for liquid and µg/kg for solids (parts per billion), metal concentrations for soils and sediments are presented in mg/kg (parts per million).

(1) Metals in both surface and subsurface soils were compared to twice the average base background positive concentrations for aluminum, barium, iron, manganese and priority pollutant metals only (priority pollutant metals include antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, zinc).

(2) Total metals in surface water and sediment were compared to the range of positive detections in upgradient samples at MCB, Camp Lejeune.

BEHP - bis(2-Ethylhexyl)phthalate

NA - Not applicable

ND - Not detected

MCL - Federal Maximum Contaminant Level. Maximum permissible level of a contaminant in water which is delivered to any user of a public water system. U.S. Environmental Protection Agency - Drinking Water Regulations and Health Advisories.

NCWQS - North Carolina Water Quality Standards. Separate Values Applicable to Groundwater (North Carolina Administrative Code, Title 15A, Subchapter 2L) and Surface Water (North Carolina Administrative Code, Title 15A, Subchapter 2B).

NOAA ER-L - USEPA Region IV Sediment Effects-Range Low Screening Values, established by the National Oceanic and Atmospheric Administration.

Soil SL - USEPA Region III Soil Screening Levels for Protection of Groundwater, established by the Office of Solid Waste Emergency Response: R.L. Smith (October 4, 1995).

TABLE 4-2
SURFACE SOIL - POSITIVE DETECTION SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA
ORGANIC COMPOUNDS

LOCATION	63-SB01-00	63-SB02-00	63-SB03-00	63-SB04-00	63-SB05-00	63-SB06-00
DATE SAMPLED	11/11/95	11/11/95	11/11/95	11/06/95	11/11/95	11/10/95
DEPTH	0-12"	0-12"	0-12"	0-12"	0-12"	0-12"
VOLATILES (ug/kg)						
METHYLENE CHLORIDE	11 U	12 U	11 U	12 U	13 U	11 U
ACETONE	11 U	12 U	11 U	12 U	13 U	11 U
SEMIVOLATILES (ug/kg)						
N-NITROSODIPHENYLAMINE (1)	370 U	400 U	360 U	400 U	430 U	370 U
DI-N-BUTYLPHTHALATE	370 U	400 U	360 U	1200 U	430 U	370 U
BIS(2-ETHYLHEXYL)PHTHALATE	370 U	400 U	360 U	63 J	430 U	370 U
PESTICIDE/PCBS (ug/kg)						
DIELDRIN	3.7 UJ	4 U	3.6 UJ	4.1 U	4.3 U	3.7 UJ
4,4'-DDE	3.7 UJ	4 U	3.6 UJ	4.1 UJ	4.3 U	3.7 UJ
4,4'-DDD	3.7 UJ	4 U	3.6 UJ	4.1 U	4.3 U	3.7 UJ
ENDOSULFAN SULFATE	3.7 UJ	4 U	3.6 UJ	4.1 U	4.3 U	3.7 UJ
4,4'-DDT	3.7 UJ	4 U	3.6 UJ	4.1 U	4.3 U	3.7 UJ
ALPHA-CHLORDANE	1.8 UJ	2 U	1.8 UJ	2 U	2.1 U	1.9 UJ
GAMMA-CHLORDANE	1.8 UJ	2 U	1.8 UJ	2 U	2.1 U	1.9 UJ
AROCLOR-1260	37 UJ	40 U	36 UJ	41 U	43 U	37 UJ

ug/kg - micrograms per kilogram
J - value is estimated
U - not detected
R - rejected

TABLE 4-2
SURFACE SOIL - POSITIVE DETECTION SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA
ORGANIC COMPOUNDS

LOCATION	63-SB07-00	63-SB08-00	63-SB09-00	63-SB10-00	63-SB11-00	63-SB12-00
DATE SAMPLED	11/11/95	11/10/95	11/10/95	11/09/95	11/09/95	11/07/95
DEPTH	0-12"	0-12"	0-12"	0-12"	0-12"	0-12"
VOLATILES (ug/kg)						
METHYLENE CHLORIDE	12 U	12 U	12 U	13 U	12 U	11 U
ACETONE	12 U	12 UJ	12 U	13 U	12 U	11 U
SEMIVOLATILES (ug/kg)						
N-NITROSODIPHENYLAMINE (1)	380 U	380 U	380 U	420 U	410 U	51 J
DI-N-BUTYLPHTHALATE	510 U	1100 U	1100 U	420 U	410 U	350 U
BIS(2-ETHYLHEXYL)PHTHALATE	380 U	380 U	380 U	420 U	410 U	4400
PESTICIDE/PCBS (ug/kg)						
DIELDRIN	3.8 UJ	3.8 UJ	3.8 UJ	4.2 U	3.7 J	3.5 U
4,4'-DDE	3.8 UJ	3.8 UJ	3.8 UJ	4.2 UJ	4.1 R	3.5 U
4,4'-DDD	3.8 UJ	3.8 UJ	3.8 UJ	4.2 U	4.1 R	3.5 U
ENDOSULFAN SULFATE	3.8 UJ	3.8 UJ	3.8 UJ	4.2 U	4.1 R	3.5 U
4,4'-DDT	3.8 UJ	3.8 UJ	3.8 UJ	2.1 J	4.1 R	3.5 U
ALPHA-CHLORDANE	1.9 UJ	1.9 UJ	1.9 UJ	2.1 U	2 R	1.8 U
GAMMA-CHLORDANE	1.9 UJ	1.9 UJ	1.9 UJ	2.1 U	2 R	1.8 U
AROCLOR-1260	38 UJ	38 UJ	38 UJ	42 U	41 R	35 U

ug/kg - micrograms per kilogram
J - value is estimated
U - not detected
R - rejected

TABLE 4-2
SURFACE SOIL - POSITIVE DETECTION SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA
ORGANIC COMPOUNDS

LOCATION	63-SB13-00	63-SB14-00	63-SB15-00	63-SB16-00	63-SB17-00	63-SB18-00
DATE SAMPLED	11/06/95	11/08/95	11/06/95	11/08/95	11/08/95	11/07/95
DEPTH	0-12"	0-12"	0-12"	0-12"	0-12"	0-12"
VOLATILES (ug/kg)						
METHYLENE CHLORIDE	11 U	11 U	14	12 U	12 U	12 UJ
ACETONE	11 U	11 U	11 U	12 U	12 U	12 UJ
SEMIVOLATILES (ug/kg)						
N-NITROSODIPHENYLAMINE (1)	350 U	380 U	380 U	390 U	380 U	410 U
DI-N-BUTYLPHTHALATE	940 U	380 U	1000 U	390 U	1700 U	410 U
BIS(2-ETHYLHEXYL)PHTHALATE	350 U	380 U	380 U	390 U	380 U	53 J
PESTICIDE/PCBS (ug/kg)						
DIELDRIN	3.5 U	3.8 UJ	3.8 U	3.9 UJ	3.9 UJ	4.1 UJ
4,4'-DDE	3.5 UJ	3.8 UJ	3.8 UJ	3.9 UJ	3.9 UJ	4.1 UJ
4,4'-DDD	3.5 U	3.8 UJ	3.8 U	3.9 UJ	3.9 UJ	4.1 UJ
ENDOSULFAN SULFATE	3.5 U	3.8 UJ	3.8 U	3.9 UJ	3.9 UJ	2.8 J
4,4'-DDT	3.5 U	3.8 UJ	3.8 U	3.9 UJ	3.9 UJ	4.1 UJ
ALPHA-CHLORDANE	1.7 U	1.9 UJ	1.9 U	1.9 UJ	1.9 UJ	2 UJ
GAMMA-CHLORDANE	1.7 U	1.9 UJ	1.9 U	1.9 UJ	1.9 UJ	2 UJ
AROCLOR-1260	35 U	38 UJ	38 U	39 UJ	39 UJ	41 UJ

ug/kg - micrograms per kilogram
J - value is estimated
U - not detected
R - rejected

TABLE 4-2
SURFACE SOIL - POSITIVE DETECTION SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA
ORGANIC COMPOUNDS

LOCATION	63-SB19-00	63-SB20-00	63-SB21-00	63-SB22-00	63-SB23-00	63-SB24-00
DATE SAMPLED	11/06/95	11/09/95	11/08/95	11/07/95	11/07/95	11/07/95
DEPTH	0-12"	0-12"	0-12"	0-12"	0-12"	0-12"
VOLATILES (ug/kg)						
METHYLENE CHLORIDE	11 U	13 U	12 U	11 U	11 U	11 U
ACETONE	11 U	13 U	12 U	11 U	11 U	11 U
SEMIVOLATILES (ug/kg)						
N-NITROSODIPHENYLAMINE (1)	350 U	2100 U	390 U	380 U	350 U	350 U
DI-N-BUTYLPHTHALATE	350 U	2100 U	630 U	1500 U	350 U	350 U
BIS(2-ETHYLHEXYL)PHTHALATE	350 U	2100 U	390 U	380 U	140 J	41 J
PESTICIDE/PCBS (ug/kg)						
DIELDRIN	3.6 U	3 J	3.8 U	3.8 U	3.6 UJ	3.5 U
4,4'-DDE	3.6 U	3 J	3.8 U	3.8 U	8.2 J	3.5 U
4,4'-DDD	3.6 U	4.3 U	3.8 U	3.8 U	3.6 UJ	3.5 U
ENDOSULFAN SULFATE	3.6 U	4.3 U	3.8 U	3.8 U	3.6 UJ	3.5 U
4,4'-DDT	3.6 U	4.3 U	3.8 J	2.7 J	10 J	2.5 J
ALPHA-CHLORDANE	1.8 U	2.1 U	1.9 U	1.9 U	1.8 UJ	1.8 U
GAMMA-CHLORDANE	1.8 U	2.1 U	1.9 U	1.9 U	1.8 UJ	1.8 U
AROCLOR-1260	36 U	43 U	28 J	38 U	36 UJ	35 U

ug/kg - micrograms per kilogram
J - value is estimated
U - not detected
R - rejected

TABLE 4-2
SURFACE SOIL - POSITIVE DETECTION SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA
ORGANIC COMPOUNDS

LOCATION	63-SB25-00	63-SB26-00	63-SB27-00	63-SB28-00	63-SB29-00	63-SB30-00
DATE SAMPLED	11/06/95	11/06/95	11/06/95	11/07/95	11/07/95	11/09/95
DEPTH	0-12"	0-12"	0-12"	0-12"	0-12"	0-12"
VOLATILES (ug/kg)						
METHYLENE CHLORIDE	34 J	11 U	20	12 U	12 U	12 U
ACETONE	10 U	11 U	11 U	12 U	12 U	12 U
SEMIVOLATILES (ug/kg)						
N-NITROSODIPHENYLAMINE (1)	340 U	360 U	370 U	400 U	390 U	380 U
DI-N-BUTYLPHTHALATE	940 U	360 U	920 U	1100 U	390 U	380 U
BIS(2-ETHYLHEXYL)PHTHALATE	340 U	120 J	370 U	400 U	65 J	380 U
PESTICIDE/PCBS (ug/kg)						
DIELDRIN	3.5 U	3.6 U	3.7 U	4 U	3.9 U	3.8 U
4,4'-DDE	3.5 UJ	3.6 U	3.7 UJ	4 U	44	3.8 U
4,4'-DDD	3.5 U	3.6 U	3.7 U	4 U	12	3.8 U
ENDOSULFAN SULFATE	3.5 U	2.5 J	3.7 U	4 U	2 J	3.8 U
4,4'-DDT	3.5 U	3.6 U	3.7 U	2 J	50 J	3.8 U
ALPHA-CHLORDANE	1.7 U	1.8 U	1.8 U	2 U	3.5	1.9 U
GAMMA-CHLORDANE	1.7 U	1.8 U	1.8 U	2 U	2.7 J	1.9 U
AROCLOR-1260	35 U	36 U	37 U	40 U	39 U	97

ug/kg - micrograms per kilogram
J - value is estimated
U - not detected
R - rejected

TABLE 4-2
SURFACE SOIL - POSITIVE DETECTION SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA
ORGANIC COMPOUNDS

LOCATION	63-SB31-00	63-SB32-00	63-SB33-00	63-SB34-00	63-SB35-00	63-SB36-00
DATE SAMPLED	11/08/95	11/09/95	11/08/95	11/07/95	11/09/95	11/09/95
DEPTH	0-12"	0-12"	0-12"	0-12"	0-12"	0-12"
VOLATILES (ug/kg)						
METHYLENE CHLORIDE	12 U	12 U	12 U	11 U	13 U	11 U
ACETONE	12 U	12 U	12 U	11 U	13 U	11 J
SEMIVOLATILES (ug/kg)						
N-NITROSODIPHENYLAMINE (1)	380 U	420 R	390 U	370 U	430 U	370 U
DI-N-BUTYLPHTHALATE	380 U	120 R	870 U	960 U	430 U	870 U
BIS(2-ETHYLHEXYL)PHTHALATE	380 U	420 R	390 U	370 U	430 U	370 U
PESTICIDE/PCBS (ug/kg)						
DIELDRIN	3.8 UJ	4.1 J	3.8 U	3.7 U	4.3 U	3.7 U
4,4'-DDE	3.8 UJ	4.1 U	3.8 U	3.7 U	55 J	3.7 U
4,4'-DDD	3.8 UJ	4.1 U	3.8 U	3.7 U	26 J	3.7 U
ENDOSULFAN SULFATE	3.8 UJ	4.1 U	3.8 U	1.9 J	4.3 U	3.7 U
4,4'-DDT	3.8 UJ	4.1 U	3.8 U	3.7 U	24	3.7 U
ALPHA-CHLORDANE	1.9 UJ	2.1 U	1.9 U	1.9 U	16	1.9 U
GAMMA-CHLORDANE	1.9 UJ	2.1 U	1.9 U	1.9 U	9	1.9 U
AROCLOR-1260	38 UJ	41 U	38 U	37 U	43 U	37 U

ug/kg - micrograms per kilogram
J - value is estimated
U - not detected
R - rejected

TABLE 4-2
SURFACE SOIL - POSITIVE DETECTION SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA
ORGANIC COMPOUNDS

LOCATION	63-SB37-00	63-SB38-00	63-TW01-00	63-TW02-00	63-TW03-00	63-TW04-00
DATE SAMPLED	11/08/95	11/08/95	11/12/95	11/11/95	11/12/95	11/10/95
DEPTH	0-12"	0-12"	0-12"	0-12"	0-12"	0-12"
VOLATILES (ug/kg)						
METHYLENE CHLORIDE	11 U	14 U	11 U	11 U	12 U	11 U
ACETONE	11 U	14 U	11 U	11 U	12 U	11 U
SEMIVOLATILES (ug/kg)						
N-NITROSODIPHENYLAMINE (1)	370 U	450 U	370 U	380 U	390 U	370 U
DI-N-BUTYLPHTHALATE	460 U	730 U	430 U	380 U	670 U	370 U
BIS(2-ETHYLHEXYL)PHTHALATE	370 U	450 U	370 U	380 U	390 U	370 U
PESTICIDE/PCBS (ug/kg)						
DIELDRIN	3.7 U	4.4 UJ	3.7 U	3.8 UJ	3.9 UJ	3.6 U
4,4'-DDE	3.7 U	4.4 UJ	3.7 U	3.8 UJ	2.7 J	3.3 J
4,4'-DDD	3.7 U	4.4 UJ	3.7 U	3.8 UJ	3.9 UJ	3.6 U
ENDOSULFAN SULFATE	3.7 U	4.4 UJ	3.7 U	3.8 UJ	3.9 UJ	3.6 U
4,4'-DDT	3.7 U	4.4 UJ	3.7 U	3.8 UJ	4.3 J	3.3 J
ALPHA-CHLORDANE	1.8 U	2.2 UJ	1.8 U	1.9 UJ	1.9 UJ	1.8 U
GAMMA-CHLORDANE	1.8 U	2.2 UJ	1.8 U	1.9 UJ	1.9 UJ	1.8 U
AROCLOR-1260	37 U	44 UJ	37 U	38 UJ	39 UJ	36 U

ug/kg - micrograms per kilogram
J - value is estimated
U - not detected
R - rejected

TABLE 4-2
SURFACE SOIL - POSITIVE DETECTION SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA
ORGANIC COMPOUNDS

LOCATION	63-TW05-00	63-TW06-00	63-TW07-00	63-TW08-00
DATE SAMPLED	11/10/95	11/10/95	11/11/95	11/09/95
DEPTH	0-12"	0-12"	0-12"	0-12"
VOLATILES (ug/kg)				
METHYLENE CHLORIDE	12 U	11 U	12 U	12 U
ACETONE	12 U	11 U	12 U	12 U
SEMIVOLATILES (ug/kg)				
N-NITROSODIPHENYLAMINE (1)	390 U	370 U	400 U	400 U
DI-N-BUTYLPHTHALATE	390 U	78 J	400 U	1100 U
BIS(2-ETHYLHEXYL)PHTHALATE	390 U	370 U	400 U	400 U
PESTICIDE/PCBS (ug/kg)				
DIELDRIN	3.9 U	3.7 U	4 U	4.1 U
4,4'-DDE	3.9 UJ	3.7 UJ	3.6 J	4.1 U
4,4'-DDD	3.9 U	3.7 U	4 U	4.1 U
ENDOSULFAN SULFATE	3.9 U	3.7 U	4 U	4.1 U
4,4'-DDT	3.9 U	3.7 U	12	4.1 U
ALPHA-CHLORDANE	1.9 U	1.8 U	2 U	2.1 U
GAMMA-CHLORDANE	1.9 U	1.8 U	2 U	2.1 U
AROCLOR-1260	39 U	37 U	40 U	41 U

ug/kg - micrograms per kilogram
J - value is estimated
U - not detected
R - rejected

TABLE 4-3
SURFACE SOIL - POSITIVE DETECTION SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA
INORGANIC ANALYTES

LOCATION	63-SB01-00	63-SB02-00	63-SB03-00	63-SB04-00	63-SB05-00	63-SB06-00
DATE SAMPLED	11/11/95	11/11/95	11/11/95	11/06/95	11/11/95	11/10/95
DEPTH	0-12"	0-12"	0-12"	0-12"	0-12"	0-12"
TOTAL ANALYTES (mg/kg)						
ALUMINUM, TOTAL	1510	2990	2400	4450 J	6080	1720
ANTIMONY, TOTAL	2.1 J	2.3 UJ	2.3 R	2.6 U	2.9 R	4.3 J
ARSENIC, TOTAL	0.29 UJ	0.53 J	0.32 UJ	1.2	1.1 J	0.46 J
BARIUM, TOTAL	7.3	8.4	14.8	17.1	23.8	6.2
BERYLLIUM, TOTAL	0.05 U	0.06 U	0.06 UJ	0.06 U	0.1 J	0.05 U
CADMIUM, TOTAL	0.68 U	0.79 U	0.79 U	0.88 U	0.98 U	0.77 U
CALCIUM, TOTAL	69.3	35.9	22.1 U	332	271	185
CHROMIUM, TOTAL	1.4	2.6	1.8 J	4.9	5.6 J	1.7
COBALT, TOTAL	0.36 U	0.42 U	0.42 U	0.55	0.51 U	0.4 U
COPPER, TOTAL	0.32 U	0.38 U	4.8	0.88 U	6.3	0.36 U
IRON, TOTAL	932	2380	1060 J	4470	5410 J	1740
LEAD, TOTAL	7.7	9	3.4 J	14.9 J	15.6 J	8.7
MAGNESIUM, TOTAL	38.2	79.7	54	178	200	71
MANGANESE, TOTAL	9	7	348 J	47.2	75.1 J	10
MERCURY, TOTAL	0.05 U	0.05 U	0.05 U	0.06 U	0.07	0.05 U
NICKEL, TOTAL	0.62 J	0.99 J	1.8	1.9	2.4	0.91 J
POTASSIUM, TOTAL	45.3	100	43.2	179	181	91.3
SELENIUM, TOTAL	0.27 UJ	0.3 UJ	0.3 U	0.31 U	0.33 U	0.32 UJ
SILVER, TOTAL	0.52 U	0.6 U	0.6 U	0.67 U	0.74 U	0.58 U
SODIUM, TOTAL	11.3 U	10.5 U	10.8	21.7 U	20.9	12.7 U
VANADIUM, TOTAL	3.1	5.1	2.2 J	8.2	9 J	3.3
ZINC, TOTAL	1.2	2.1	2.9	5.6	7.7	2.9

mg/kg - milligrams per kilogram
J - value is estimated
U - not detected
R - rejected

TABLE 4-3
SURFACE SOIL - POSITIVE DETECTION SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA
INORGANIC ANALYTES

LOCATION	63-SB07-00	63-SB08-00	63-SB09-00	63-SB10-00	63-SB11-00	63-SB12-00
DATE SAMPLED	11/11/95	11/10/95	11/10/95	11/09/95	11/09/95	11/07/95
DEPTH	0-12"	0-12"	0-12"	0-12"	0-12"	0-12"
TOTAL ANALYTES (mg/kg)						
ALUMINUM, TOTAL	2550	2570	2850	5950 J	1320 J	1670 J
ANTIMONY, TOTAL	2.4 UJ	2.1 UJ	2 UJ	5 U	5 U	2.3 UJ
ARSENIC, TOTAL	0.47 J	1.2 J	0.6 J	0.88 J	0.36	0.34 U
BARIUM, TOTAL	6.4	7.9	8.2	18.8	4.7	5.4
BERYLLIUM, TOTAL	0.06 U	0.051 U	0.05 U	0.21 U	0.21 U	0.06 U
CADMIUM, TOTAL	0.81 U	0.71 U	0.69 U	0.45 U	0.44 U	0.78 U
CALCIUM, TOTAL	51.4	127	103	154	42.2	42.6 U
CHROMIUM, TOTAL	1.5	2.2	2.4	5.2	1.2	1.7
COBALT, TOTAL	0.42 U	0.37 U	0.36 U	1.1	0.72 U	0.41 U
COPPER, TOTAL	0.39 U	0.55	0.33 U	1.1	0.47	0.89
IRON, TOTAL	1960	2410	2050	3200	973	1220 J
LEAD, TOTAL	2.6	7	6.9	13 J	5.1 J	3.9
MAGNESIUM, TOTAL	62.4	80.6	88.3	168	49.7	44.4
MANGANESE, TOTAL	14.2	21.9	6.7	29.6	6.7	18.6
MERCURY, TOTAL	0.06 U	0.05 U	0.06	0.06 U	0.06 U	0.05 U
NICKEL, TOTAL	0.71 U	0.62 U	1 J	3.4	2.3 U	0.87
POTASSIUM, TOTAL	71.5	77.5	84.2	167 U	166 U	40.8 J
SELENIUM, TOTAL	0.32 UJ	0.28 UJ	0.28 UJ	0.27	0.31 U	0.32 UJ
SILVER, TOTAL	0.62 U	0.54 U	0.52 U	0.62 U	0.61 U	0.72
SODIUM, TOTAL	10.1 U	11.5 U	15.5 U	17 U	10.2 U	10.8 U
VANADIUM, TOTAL	3.1	4.7	4.5	8.6	2.5	2.1
ZINC, TOTAL	2	2.3	2.9	6.9	3.8 U	3.3 U

mg/kg - milligrams per kilogram
J - value is estimated
U - not detected
R - rejected

TABLE 4-3
SURFACE SOIL - POSITIVE DETECTION SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA
INORGANIC ANALYTES

LOCATION	63-SB13-00	63-SB14-00	63-SB15-00	63-SB16-00	63-SB17-00	63-SB18-00
DATE SAMPLED	11/06/95	11/08/95	11/06/95	11/08/95	11/08/95	11/07/95
DEPTH	0-12"	0-12"	0-12"	0-12"	0-12"	0-12"
TOTAL ANALYTES (mg/kg)						
ALUMINUM, TOTAL	1040 J	1440	2110 J	3700	2670	7050 J
ANTIMONY, TOTAL	2.2 U	3.2 J	2.4 U	2.3 UJ	2.3 UJ	2.6 UJ
ARSENIC, TOTAL	0.51	0.36 U	0.43	1.7	0.82	1.4
BARIUM, TOTAL	3	3.5	4.6	8.5	5.9	27.3
BERYLLIUM, TOTAL	0.05 U	0.07 U	0.06 U	0.2	0.06 U	0.1
CADMIUM, TOTAL	0.76 U	0.95 U	0.82 U	0.77 U	0.78 U	0.87 U
CALCIUM, TOTAL	29.2	26.3	13.2	10.4	36.4	289 J
CHROMIUM, TOTAL	1.7	1.6	2.6	7.4	4	6.8
COBALT, TOTAL	0.4 U	0.5 UJ	0.43 U	0.4 UJ	0.41 UJ	0.46 U
COPPER, TOTAL	0.68 U	0.45 UJ	0.39 U	5.9 J	1.4 J	2.3
IRON, TOTAL	1220	2230	1290	3120	2590	4870 J
LEAD, TOTAL	9.8 J	6.7	7.2 J	7.6	5.6	15.9
MAGNESIUM, TOTAL	38.5	37.1	48.4	197	127	217
MANGANESE, TOTAL	4.1	5.9	6.4	7.3	10.4	14.2
MERCURY, TOTAL	0.04 U	0.05 U	0.05 U	0.05 U	0.05 U	0.06 U
NICKEL, TOTAL	0.67 U	0.84 U	0.72 U	0.74	0.94	2.2
POTASSIUM, TOTAL	58.1	55 U	55.4	341	218	164 J
SELENIUM, TOTAL	0.27 U	0.34 U	0.32 U	0.34 U	0.32 U	0.35 UJ
SILVER, TOTAL	0.58 U	0.72 U	0.63 U	0.59 U	0.6 U	0.66 U
SODIUM, TOTAL	5.8 U	5.2 U	13.2 U	5.8 U	8.6 U	34.7
VANADIUM, TOTAL	2.5	3.4	4.6	8.9	6.2	11
ZINC, TOTAL	2.2 U	1.5	2.5 U	7.6	3.9	10.4

mg/kg - milligrams per kilogram
J - value is estimated
U - not detected
R - rejected

TABLE 4-3
SURFACE SOIL - POSITIVE DETECTION SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA
INORGANIC ANALYTES

LOCATION	63-SB19-00	63-SB20-00	63-SB21-00	63-SB22-00	63-SB23-00	63-SB24-00
DATE SAMPLED	11/06/95	11/09/95	11/08/95	11/07/95	11/07/95	11/07/95
DEPTH	0-12"	0-12"	0-12"	0-12"	0-12"	0-12"
TOTAL ANALYTES (mg/kg)						
ALUMINUM, TOTAL	869 J	1840 J	4050	3250	1400 J	1300 J
ANTIMONY, TOTAL	2.4 J	3.8 U	2.2 UJ	3 J	2.5 UJ	2.6 J
ARSENIC, TOTAL	0.27 U	0.64	3.7	1.3	1.1	0.5
BARIUM, TOTAL	3.7	5.8	25.3	9.2	4.5	34.6
BERYLLIUM, TOTAL	0.06 U	0.16 U	0.05 U	0.07 U	0.06 U	0.05 U
CADMIUM, TOTAL	0.79 U	0.34 U	3.1	0.94 U	0.85 U	0.72 U
CALCIUM, TOTAL	34.3 U	1840	185	46.5 U	2780 J	89.8 U
CHROMIUM, TOTAL	1.1	4.2	11.1	5.5	2.9	1.8
COBALT, TOTAL	0.42 U	0.55 U	2.3 J	0.49 UJ	0.49	0.38 U
COPPER, TOTAL	0.38 U	10	31.2	7.9 J	10.3	11.2
IRON, TOTAL	1650 J	4180	22400 J	4010 J	1560 J	1510 J
LEAD, TOTAL	5.1	11.6 J	58.2	14.7	27.6	9.2
MAGNESIUM, TOTAL	28.4	199	129	139	47.8	42.2
MANGANESE, TOTAL	13.7	49.5	134 J	6.9 J	13.1	13.9
MERCURY, TOTAL	0.04 U	0.08	0.06 U	0.05 U	0.21 J	0.05 U
NICKEL, TOTAL	1.1	2.3	9.8	1.5	1.6	1.9
POTASSIUM, TOTAL	47.8 J	128 U	349	198 J	21.8 J	47.1 J
SELENIUM, TOTAL	0.26 UJ	0.26 U	0.31 U	0.27 U	0.24 UJ	0.32 UJ
SILVER, TOTAL	0.6 U	0.47 U	0.58 U	0.72 U	0.65 U	0.55 U
SODIUM, TOTAL	7.3 U	100	41.1	5.3	5.2 U	5.1 U
VANADIUM, TOTAL	2.1	3.2	10	8	2.5	3
ZINC, TOTAL	0.98	182	1860	6.7	64.2	13.1

mg/kg - milligrams per kilogram
J - value is estimated
U - not detected
R - rejected

TABLE 4-3
SURFACE SOIL - POSITIVE DETECTION SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA
INORGANIC ANALYTES

LOCATION	63-SB25-00	63-SB26-00	63-SB27-00	63-SB28-00	63-SB29-00	63-SB30-00
DATE SAMPLED	11/06/95	11/06/95	11/06/95	11/07/95	11/07/95	11/09/95
DEPTH	0-12"	0-12"	0-12"	0-12"	0-12"	0-12"
TOTAL ANALYTES (mg/kg)						
ALUMINUM, TOTAL	952 J	686 J	1210 J	4900	3420 J	2870
ANTIMONY, TOTAL	2.6 U	2.4 UJ	1.9 U	2 UJ	2.9 UJ	2.6 UJ
ARSENIC, TOTAL	0.3 U	0.43	0.27 U	0.71	1.1	0.59
BARIUM, TOTAL	6.2	3.6	5.4	7.5	25.6	10.4
BERYLLIUM, TOTAL	0.06 U	0.06 U	0.05 U	0.05 U	0.15	0.06 U
CADMIUM, TOTAL	0.89 U	0.8 U	0.63 U	0.68 U	0.98 U	0.87 U
CALCIUM, TOTAL	247	17.4 U	16.8	18.2 U	208 U	138
CHROMIUM, TOTAL	4.2	1.4	2.2	6.5	9.1	4.5
COBALT, TOTAL	0.65	0.42 U	0.33 U	0.36 UJ	4.3	0.46 UJ
COPPER, TOTAL	8.2	0.38 U	0.3 U	6.8 J	74.8	8.2 J
IRON, TOTAL	825	1320 J	1100	1350 J	20400 J	2460
LEAD, TOTAL	8.3 J	6.3	8.7 J	8	107	17.5
MAGNESIUM, TOTAL	45.4	33.1	44.3	124	223	119
MANGANESE, TOTAL	20.5	7.6	3.6	3.4 J	90.1	15
MERCURY, TOTAL	0.05 U	0.05 U	0.05 U	0.06 U	0.05 U	0.05 U
NICKEL, TOTAL	2.1	1.5	0.56 U	1.3	8.3	0.95
POTASSIUM, TOTAL	40.6	23 J	65.2	199 J	213 J	181
SELENIUM, TOTAL	0.28 U	0.27 UJ	0.25 U	0.27 U	0.31 UJ	0.33 U
SILVER, TOTAL	0.67 U	0.61 U	0.48 U	0.52 U	0.97	0.66 U
SODIUM, TOTAL	7.8 U	4.4 U	11.7 U	3.7 U	18.5 U	6.3 U
VANADIUM, TOTAL	2.1	2.6	2.9	7.6	8.6	6
ZINC, TOTAL	9.5	1.8 U	2.1 U	4.9	48.5	7.3

mg/kg - milligrams per kilogram
J - value is estimated
U - not detected
R - rejected

TABLE 4-3
SURFACE SOIL - POSITIVE DETECTION SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA
INORGANIC ANALYTES

LOCATION	63-SB31-00	63-SB32-00	63-SB33-00	63-SB34-00	63-SB35-00	63-SB36-00
DATE SAMPLED	11/08/95	11/09/95	11/08/95	11/07/95	11/09/95	11/09/95
DEPTH	0-12"	0-12"	0-12"	0-12"	0-12"	0-12"
TOTAL ANALYTES (mg/kg)						
ALUMINUM, TOTAL	577	6300	4040	3340	2110 J	2190
ANTIMONY, TOTAL	2.6 UJ	2.8 UJ	2.7 UJ	2.5 UJ	3.9 U	2.6 J
ARSENIC, TOTAL	0.36 U	0.57	0.84	0.34	0.94	0.51
BARIUM, TOTAL	7.4	34.8	10.3	6.2	53.1	7.4
BERYLLIUM, TOTAL	0.06 U	0.27	0.07 U	0.06 U	0.17 U	0.06 U
CADMIUM, TOTAL	0.89 U	0.94 U	0.92 U	0.84 U	0.35 U	0.84 U
CALCIUM, TOTAL	135	173	28.4 U	74.4	208	116
CHROMIUM, TOTAL	0.97 U	3.9	6.6	3.9	3.8	2
COBALT, TOTAL	0.46 UJ	0.49 UJ	0.48 UJ	0.44 UJ	0.62	0.44 UJ
COPPER, TOTAL	0.42 UJ	6.2 J	0.61 J	5.1 J	24.5	0.4 UJ
IRON, TOTAL	590	3500	3320 J	1620 J	5090	1350
LEAD, TOTAL	5.8	11.2	7.8	6.1	53 J	3.7 J
MAGNESIUM, TOTAL	30.1	124	114	106	89	48.4
MANGANESE, TOTAL	8	8	15.7 J	12.7 J	17	13.4
MERCURY, TOTAL	0.05 U	0.04 U	0.06 U	0.05 U	0.04 U	0.05 U
NICKEL, TOTAL	0.78 U	1.6	0.99	2.4	1.9	0.74 U
POTASSIUM, TOTAL	37.6 U	199	192 J	121 J	131 U	49.8 U
SELENIUM, TOTAL	0.34 U	0.33 U	0.3 U	0.26 U	0.3 U	0.33
SILVER, TOTAL	0.68 U	0.72 U	0.7 U	0.64 U	0.48 U	0.64 U
SODIUM, TOTAL	4.9 U	47 U	5 U	4.6 U	11.2 U	4.6 U
VANADIUM, TOTAL	1.4 U	8.5	9.4	5.5	5.1	2.8
ZINC, TOTAL	2	7.9	4.2 U	12.1	38.5	1.5

mg/kg - milligrams per kilogram
J - value is estimated
U - not detected
R - rejected

TABLE 4-3
SURFACE SOIL - POSITIVE DETECTION SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA
INORGANIC ANALYTES

LOCATION	63-SB37-00	63-SB38-00	63-TW01-00	63-TW02-00	63-TW03-00	63-TW04-00
DATE SAMPLED	11/08/95	11/08/95	11/12/95	11/11/95	11/12/95	11/10/95
DEPTH	0-12"	0-12"	0-12"	0-12"	0-12"	0-12"
TOTAL ANALYTES (mg/kg)						
ALUMINUM, TOTAL	1180	3630	2270	2730	1840	1370 J
ANTIMONY, TOTAL	2.5 UJ	3.1 UJ	2.7 R	2.3 R	2.4 R	4.2 U
ARSENIC, TOTAL	0.45	0.8	0.31 UJ	0.52 J	0.35 J	0.32
BARIUM, TOTAL	5.3	11.1	7.3	7.7	4.4	3.2
BERYLLIUM, TOTAL	0.06 U	0.07 U	0.07 UJ	0.06 UJ	0.06 UJ	0.18 U
CADMIUM, TOTAL	0.86 U	1 U	0.92 U	0.78 U	0.8 U	0.38 U
CALCIUM, TOTAL	89.3	431	173	50.5	76.4	33.2 U
CHROMIUM, TOTAL	1.1	3.6	1.9 J	2.3 J	2.5 J	1.7
COBALT, TOTAL	0.45 UJ	0.55 UJ	0.48 U	0.41 U	0.42 U	0.61 U
COPPER, TOTAL	0.41 UJ	0.5 UJ	6	3.6	4.1	0.64
IRON, TOTAL	732 J	2450	1740 J	2160 J	1480 J	1450
LEAD, TOTAL	5.8	13.5	7.5 J	7.7 J	6.5 J	7 J
MAGNESIUM, TOTAL	33.5	161	64.5	80	52.7 J	39.5
MANGANESE, TOTAL	9.7 J	11.5	33 J	60.3 J	13.9 J	4
MERCURY, TOTAL	0.05 U	0.06 U	0.04 U	0.04 U	0.04 U	0.04 U
NICKEL, TOTAL	1.4	1.3	0.81 U	0.85	0.71 U	2 U
POTASSIUM, TOTAL	18.9 J	227	73.1	77.2	64.5	142 U
SELENIUM, TOTAL	0.29 U	0.37 U	0.29 U	0.28 U	0.29 U	0.26 U
SILVER, TOTAL	0.65 U	0.79 U	0.7 U	0.59 U	0.61 U	0.52 U
SODIUM, TOTAL	4.7 U	34.1 U	5.1 U	4.3 U	4.4 U	10.5 U
VANADIUM, TOTAL	2	7.6	3.4 J	3.3 J	4 J	2.5
ZINC, TOTAL	3.2 U	7.2	6.2	2.9	2.9	2.8 U

mg/kg - milligrams per kilogram
J - value is estimated
U - not detected
R - rejected

TABLE 4-3
SURFACE SOIL - POSITIVE DETECTION SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA
INORGANIC ANALYTES

LOCATION	63-TW05-00	63-TW06-00	63-TW07-00	63-TW08-00
DATE SAMPLED	11/10/95	11/10/95	11/11/95	11/09/95
DEPTH	0-12"	0-12"	0-12"	0-12"
TOTAL ANALYTES (mg/kg)				
ALUMINUM, TOTAL	3840 J	268 J	5040	4520
ANTIMONY, TOTAL	4.7 U	4.5 U	2.2 R	3.7 J
ARSENIC, TOTAL	1.9	0.33 U	1.4 J	0.63
BARIUM, TOTAL	5.2	5.6	16.8	9.2
BERYLLIUM, TOTAL	0.2 U	0.19 U	0.05 UJ	0.07 U
CADMIUM, TOTAL	0.42 U	0.4 U	0.74 U	1
CALCIUM, TOTAL	36.6	350	233	244
CHROMIUM, TOTAL	6.7	0.4 U	7.6 J	5
COBALT, TOTAL	0.67 U	0.65 U	0.39 U	0.52 UJ
COPPER, TOTAL	2.9	0.68	16	0.48 UJ
IRON, TOTAL	3440	621	4270 J	2120
LEAD, TOTAL	7.2 J	5 J	46.3 J	8.7
MAGNESIUM, TOTAL	127	37.3	223	124
MANGANESE, TOTAL	5.8	36.7	14.7 J	8.9
MERCURY, TOTAL	0.06 U	0.04 U	0.04 U	0.05 U
NICKEL, TOTAL	2.8	2.1 U	1.4	1.7
POTASSIUM, TOTAL	275	149 U	284	138 U
SELENIUM, TOTAL	0.26 U	0.31 U	0.32 U	0.34 U
SILVER, TOTAL	0.57 U	0.55 U	0.56 U	0.76 U
SODIUM, TOTAL	13.4 U	7.3 U	14.9	10.1 U
VANADIUM, TOTAL	9.3	0.61 U	9.6 J	6.4
ZINC, TOTAL	4.3 U	337	27.6	3.4

mg/kg - milligrams per kilogram
J - value is estimated
U - not detected
R - rejected

TABLE 4-4
SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA
ORGANIC COMPOUNDS

LOCATION	63-SB01-04	63-SB02-04	63-SB03-05	63-SB03-06	63-SB04-03	63-SB05-03
DATE SAMPLED	11/11/95	11/11/95	11/11/95	11/11/95	11/06/95	11/11/95
DEPTH	7-9'	7-9'	9-11'	11-13'	5-7'	5-7'
VOLATILES (ug/kg)						
METHYLENE CHLORIDE	13 U	13 U	13 U	13 U	13 U	13 U
ACETONE	13 U	13 U	13 U	13 U	82 J	13 U
STYRENE	13 U	13 U	13 U	13 U	13 U	13 U
SEMIVOLATILES (ug/kg)						
N-NITROSODIPHENYLAMINE (1)	430 U	420 U	440 U	450 U	420 U	430 U
BIS(2-ETHYLHEXYL)PHTHALATE	430 U	420 U	440 U	450 U	420 U	430 U
PESTICIDE/PCBS (ug/kg)						
DIELDRIN	4.3 UJ	4.2 UJ	4.4 U	4.5 U	4.2 U	4.3 U
4,4'-DDE	4.3 UJ	4.2 UJ	4.4 U	4.5 U	4.2 UJ	4.3 U
4,4'-DDD	4.3 UJ	4.2 UJ	4.4 U	4.5 U	4.2 U	4.3 U
4,4'-DDT	4.3 UJ	4.2 UJ	4.4 U	4.5 U	4.2 U	4.3 U

ug/kg - micrograms per kilogram
J - value is estimated
U - not detected
R - rejected

TABLE 4-4
SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA
ORGANIC COMPOUNDS

LOCATION	63-SB05-06	63-SB06-01	63-SB07-04	63-SB08-05	63-SB08-07	63-SB09-03
DATE SAMPLED	11/11/95	11/10/95	11/11/95	11/10/95	11/10/95	11/10/95
DEPTH	11-13'	1-3'	7-9'	9-11'	13-15'	5-7'
VOLATILES (ug/kg)						
METHYLENE CHLORIDE	14 U	12 U	14 U	13 U	14 U	12 U
ACETONE	14 U	12 U	14 U	13 UJ	23 J	12 UJ
STYRENE	14 U	12 U	14 U	13 U	14 U	12 U
SEMIVOLATILES (ug/kg)						
N-NITROSODIPHENYLAMINE (1)	450 U	400 U	450 U	420 U	450 U	380 U
BIS(2-ETHYLHEXYL)PHTHALATE	450 U	400 U	450 U	54 J	450 U	380 U
PESTICIDE/PCBS (ug/kg)						
DIELDRIN	4.5 U	4 UJ	4.5 UJ	4.2 U	4.5 UJ	3.8 UJ
4,4'-DDE	4.5 U	4 UJ	4.5 UJ	4.2 U	4.5 UJ	3.8 UJ
4,4'-DDD	4.5 U	4 UJ	4.5 UJ	4.2 U	4.5 UJ	3.8 UJ
4,4'-DDT	4.5 U	4 UJ	4.5 UJ	4.2 U	4.5 UJ	3.8 UJ

ug/kg - micrograms per kilogram
J - value is estimated
U - not detected
R - rejected

TABLE 4-4
SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA
ORGANIC COMPOUNDS

LOCATION	63-SB09-06	63-SB10-02	63-SB11-05	63-SB12-04	63-SB13-03	63-SB13-05
DATE SAMPLED	11/10/95	11/09/95	11/09/95	11/07/95	11/06/95	11/06/95
DEPTH	11-13'	3-5'	9-11'	7-9'	5-7'	9-11'
VOLATILES (ug/kg)						
METHYLENE CHLORIDE	13 U	13 U	13 U	13 U	20	47
ACETONE	13 UJ	13 U	13 U	13 U	48 J	47 J
STYRENE	13 U	13 U	13 U	13 U	12 U	13 U
SEMIVOLATILES (ug/kg)						
N-NITROSODIPHENYLAMINE (1)	440 U	420 U	430 U	420 U	400 U	420 U
BIS(2-ETHYLHEXYL)PHTHALATE	440 U	420 U	430 U	97 J	41 J	980
PESTICIDE/PCBS (ug/kg)						
DIELDRIN	4.4 UJ	2.1 J	4.3 U	4.2 U	4 UJ	4.2 UJ
4,4'-DDE	4.4 UJ	4.3 UJ	4.3 UJ	4.2 U	4 UJ	4.2 UJ
4,4'-DDD	4.4 UJ	4.3 U	4.3 U	4.2 U	4 UJ	4.2 UJ
4,4'-DDT	4.4 UJ	4.3 U	4.3 U	4.2 U	4 UJ	4.2 UJ

ug/kg - micrograms per kilogram
J - value is estimated
U - not detected
R - rejected

TABLE 4-4
SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA
ORGANIC COMPOUNDS

LOCATION	63-SB14-04	63-SB15-04	63-SB16-02	63-SB17-03	63-SB18-05	63-SB19-03
DATE SAMPLED	11/08/95	11/06/95	11/08/95	11/08/95	11/07/95	11/06/95
DEPTH	7-9'	7-9'	3-5'	5-7'	9-11'	5-7'
VOLATILES (ug/kg)						
METHYLENE CHLORIDE	13 U	24	12 U	12 U	12 U	12 U
ACETONE	13 U	57 J	12 U	12 UJ	12 U	12 U
STYRENE	13 U	41	12 U	12 U	12 UJ	12 U
SEMIVOLATILES (ug/kg)						
N-NITROSODIPHENYLAMINE (1)	420 U	420 U	400 U	94 J	400 U	350 J
BIS(2-ETHYLHEXYL)PHTHALATE	420 U	770	400 U	2200 U	400 U	4700
PESTICIDE/PCBS (ug/kg)						
DIELDRIN	4.2 UJ	4.2 U	4 UJ	4.2 UJ	4 U	4 U
4,4'-DDE	4.2 UJ	4.2 UJ	4 UJ	4.2 UJ	4 U	4 U
4,4'-DDD	4.2 UJ	4.2 U	4 UJ	4.2 UJ	4 U	4 U
4,4'-DDT	4.2 UJ	4.2 U	4 UJ	4.2 UJ	4 U	4 U

ug/kg - micrograms per kilogram
J - value is estimated
U - not detected
R - rejected

TABLE 4-4
SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA
ORGANIC COMPOUNDS

LOCATION	63-SB20-01	63-SB21-03	63-SB22-03	63-SB23-03	63-SB24-03	63-SB25-03
DATE SAMPLED	11/09/95	11/08/95	11/07/95	11/07/95	11/07/95	11/06/95
DEPTH	1-3'	5-7'	5-7'	5-7'	5-7'	5-7'
VOLATILES (ug/kg)						
METHYLENE CHLORIDE	11 U	12 U	12 U	12 U	12 U	100
ACETONE	11 U	12 U	12 U	12 U	12 U	150 J
STYRENE	11 U	12 U	12 U	12 UJ	12 U	12 U
SEMIVOLATILES (ug/kg)						
N-NITROSODIPHENYLAMINE (1)	370 U	400 U	400 U	390 U	390 U	390 U
BIS(2-ETHYLHEXYL)PHTHALATE	210 J	400 U	400 U	120 J	390 U	390 U
PESTICIDE/PCBS (ug/kg)						
DIELDRIN	3.7 U	4 U	4 U	3.9 U	3.9 U	3.9 U
4,4'-DDE	2.6 J	4 U	2.8 J	3.9 U	3.9 U	3.9 UJ
4,4'-DDD	3.7 U	4 U	5.6	3.9 U	3.9 U	3.9 U
4,4'-DDT	7.8	4 U	4 U	3.9 U	3.9 U	3.9 U

ug/kg - micrograms per kilogram
J - value is estimated
U - not detected
R - rejected

TABLE 4-4
SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA
ORGANIC COMPOUNDS

LOCATION	63-SB26-03	63-SB27-02	63-SB28-02	63-SB29-03	63-SB30-03	63-SB31-04
DATE SAMPLED	11/06/95	11/06/95	11/07/95	11/07/95	11/09/95	11/08/95
DEPTH	5-7'	3-5'	3-5'	5-7'	5-7'	7-9'
VOLATILES (ug/kg)						
METHYLENE CHLORIDE	12 U	26	12 U	13 U	12 U	13 U
ACETONE	12 U	32	12 U	13 U	12 U	13 U
STYRENE	12 U	13 U	12 U	13 U	12 U	13 U
SEMIVOLATILES (ug/kg)						
N-NITROSODIPHENYLAMINE (1)	400 U	410 U	390 U	430 U	380 R	410 U
BIS(2-ETHYLHEXYL)PHTHALATE	230 J	410 U	390 U	54 J	380 R	410 U
PESTICIDE/PCBS (ug/kg)						
DIELDRIN	4 U	4.2 U	3.9 U	4.3 U	3.8 U	4.1 UJ
4,4'-DDE	4 U	4.2 UJ	3.9 U	4.3 U	3.8 U	4.1 UJ
4,4'-DDD	4 U	4.2 U	3.9 U	4.3 U	3.8 U	4.1 UJ
4,4'-DDT	4 U	4.2 U	3.9 U	4.3 U	3.8 U	4.1 UJ

ug/kg - micrograms per kilogram
J - value is estimated
U - not detected
R - rejected

TABLE 4-4
SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA
ORGANIC COMPOUNDS

LOCATION	63-SB32-02	63-SB33-02	63-SB34-05	63-SB36-02	63-SB37-04	63-SB38-02
DATE SAMPLED	11/09/95	11/08/95	11/07/95	11/09/95	11/08/95	11/08/95
DEPTH	3-5'	3-5'	9-11'	3-5'	7-9'	3-5'
VOLATILES (ug/kg)						
METHYLENE CHLORIDE	13 U	12 U	13 UJ	12 U	13 U	13 U
ACETONE	13 U	12 U	13 UJ	12 U	13 U	13 U
STYRENE	13 U	12 U	13 UJ	12 U	13 U	13 U
SEMIVOLATILES (ug/kg)						
N-NITROSODIPHENYLAMINE (1)	420 U	410 U	440 U	400 U	430 U	420 U
BIS(2-ETHYLHEXYL)PHTHALATE	420 U	410 U	440 U	400 U	360 NA	420 U
PESTICIDE/PCBS (ug/kg)						
DIELDRIN	5 J	4.1 U	4.4 U	3.9 U	4.2 U	4.1 UJ
4,4'-DDE	4.2 U	4.1 U	4.4 U	3.9 U	4.2 U	4.1 UJ
4,4'-DDD	4.2 U	4.1 U	4.4 U	3.9 U	4.2 U	4.1 UJ
4,4'-DDT	4.2 U	4.1 U	4.4 U	3.9 U	4.2 U	4.1 UJ

ug/kg - micrograms per kilogram
J - value is estimated
U - not detected
R - rejected

TABLE 4-4
SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA
ORGANIC COMPOUNDS

LOCATION	63-TW01-01	63-TW02-04	63-TW03-03	63-TW04-03	63-TW05-02	63-TW06-02
DATE SAMPLED	11/12/95	11/11/95	11/12/95	11/10/95	11/10/95	11/10/95
DEPTH	1-3'	7-9'	5-7'	5-7'	3-5'	3-5'
VOLATILES (ug/kg)						
METHYLENE CHLORIDE	12 U	13 U	12 U	12 U	12 U	13 U
ACETONE	12 U	13 U	12 U	12 U	12 U	13 U
STYRENE	12 U	13 U	12 U	12 U	12 U	13 U
SEMIVOLATILES (ug/kg)						
N-NITROSODIPHENYLAMINE (1)	390 U	440 U	410 U	390 U	400 U	410 U
BIS(2-ETHYLHEXYL)PHTHALATE	390 U	61 J	410 U	390 U	400 U	410 U
PESTICIDE/PCBS (ug/kg)						
DIELDRIN	3.9 UJ	4.4 U	4.1 UJ	3.8 U	4 U	4.2 U
4,4'-DDE	3.9 UJ	4.4 U	4.1 UJ	3.8 UJ	4 UJ	4.2 UJ
4,4'-DDD	3.9 UJ	4.4 U	4.1 UJ	3.8 U	4 U	4.2 U
4,4'-DDT	3.9 UJ	4.4 U	4.1 UJ	3.8 U	4 U	4.2 U

ug/kg - micrograms per kilogram
J - value is estimated
U - not detected
R - rejected

TABLE 4-4
SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA
ORGANIC COMPOUNDS

LOCATION	63-TW07-01	63-TW08-03
DATE SAMPLED	11/11/95	11/09/95
DEPTH	1-3'	5-7'
VOLATILES (ug/kg)		
METHYLENE CHLORIDE	12 U	13 U
ACETONE	12 U	13 U
STYRENE	12 U	13 U
SEMIVOLATILES (ug/kg)		
N-NITROSODIPHENYLAMINE (1)	390 U	420 U
BIS(2-ETHYLHEXYL)PHTHALATE	390 U	420 U
PESTICIDE/PCBS (ug/kg)		
DIELDRIN	3.9 U	4.3 U
4,4'-DDE	3.9 U	4.3 U
4,4'-DDD	3.9 U	4.3 U
4,4'-DDT	3.9 U	4.3 U

ug/kg - micrograms per kilogram
J - value is estimated
U - not detected
R - rejected

TABLE 4-5
SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA
INORGANIC ANALYTES

LOCATION	63-SB01-04	63-SB02-04	63-SB03-05	63-SB03-06	63-SB04-03	63-SB05-03
DATE SAMPLED	11/11/95	11/11/95	11/11/95	11/11/95	11/06/95	11/11/95
DEPTH	7-9'	7-9'	9-11'	11-13'	5-7'	5-7'
TOTAL METALS (mg/kg)						
ALUMINUM, TOTAL	9900	9710	13200	10400	13100 J	15400
ANTIMONY, TOTAL	2.3 UJ	4.9 J	2.7 R	3.2 R	3.1 U	3 R
ARSENIC, TOTAL	2.3 J	6 J	7.8 J	3.6 J	3.4	0.69 J
BARIUM, TOTAL	9.2	10.6	11.4	10.9	14	13.1
BERYLLIUM, TOTAL	0.14	0.15	0.19 J	0.12 J	0.08 U	0.11 J
CALCIUM, TOTAL	6.9	17.1	32.7 U	30.9 U	29.4	37
CHROMIUM, TOTAL	12.4	13.9	27.1 J	25.9 J	16.1	20 J
COBALT, TOTAL	0.41 U	0.45 U	0.48 U	0.59	0.8	0.66
COPPER, TOTAL	4.1	1.3	7.6	8.8	1.4 U	7.8
IRON, TOTAL	4420	6430	20700 J	27600 J	4590	8290 J
LEAD, TOTAL	6.8	6.5	8.3 J	7.9 J	7.7 J	7.1 J
MAGNESIUM, TOTAL	264	338	473	404	476	513
MANGANESE, TOTAL	5.1	6.9	10.3 J	9.5 J	9.3	7.9 J
NICKEL, TOTAL	1.2 J	1.3 J	1.4	0.96 U	1.5	1.4
POTASSIUM, TOTAL	641	615	855	846	741	751
SELENIUM, TOTAL	0.33 UJ	0.38 UJ	0.31 J	0.37 U	0.36 U	0.29 U
SILVER, TOTAL	0.6 U	0.66 U	0.69 U	0.83 U	0.81 U	0.78 U
SODIUM, TOTAL	31 U	27.9 U	28	29.8	29.9	28
THALLIUM, TOTAL	0.13 U	0.15 U	0.12 U	0.15 U	0.15 UJ	0.18
VANADIUM, TOTAL	12.2	21.4	37.7 J	27.2 J	17.8	26.1 J
ZINC, TOTAL	5.6	5	9.9	11.8	6.5	5.2

mg/kg - milligrams per kilogram
J - value is estimated
U - not detected
R - rejected

TABLE 4-5
SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA
INORGANIC ANALYTES

LOCATION	63-SB05-06	63-SB06-01	63-SB07-04	63-SB08-05	63-SB08-07	63-SB09-03
DATE SAMPLED	11/11/95	11/10/95	11/11/95	11/10/95	11/10/95	11/10/95
DEPTH	11-13'	1-3'	7-9'	9-11'	13-15'	5-7'
TOTAL METALS (mg/kg)						
ALUMINUM, TOTAL	12900	12200	16000	11300	11900	9330
ANTIMONY, TOTAL	2.3 R	2.1 UJ	4.4 J	2.7 UJ	2.5 J	3.6 J
ARSENIC, TOTAL	1.7 J	0.68 J	2.5 J	2.3 J	5.4 J	3.4 J
BARIUM, TOTAL	10.7	25.3	15.1	12.7	16	8.7
BERYLLIUM, TOTAL	0.15 J	0.05 U	0.21	0.07 U	0.22	0.05 U
CALCIUM, TOTAL	46.8	271	55.9	6.4	61.9	15.8
CHROMIUM, TOTAL	19.7 J	10.5	23.9	23.1	19.9	10.6
COBALT, TOTAL	0.77	0.45	0.47 U	0.49 U	10.4	0.35 U
COPPER, TOTAL	8.1	1.1	8.6	6.8	7.3	0.32 U
IRON, TOTAL	9740 J	6380	12500	18200	9530	4970
LEAD, TOTAL	7.4 J	6.8	8.1	7.6	8.9	6
MAGNESIUM, TOTAL	438	337	552	323	511	215
MANGANESE, TOTAL	9 J	6	10	5.6	67.9	3.5
NICKEL, TOTAL	2.5	2.9 J	3.9 J	1.2 J	13.9 J	0.59 U
POTASSIUM, TOTAL	855	291	1040	808	1050	477
SELENIUM, TOTAL	0.32 U	0.25 UJ	0.37 UJ	0.32 UJ	0.4 UJ	0.31 UJ
SILVER, TOTAL	0.61 U	0.56 U	0.69 U	0.71 U	0.63 U	0.51 U
SODIUM, TOTAL	27.6	23.1 U	28.4 U	42.3	45.2	19.5 U
THALLIUM, TOTAL	0.13 U	0.14	0.18	0.13 U	0.16 U	0.12 U
VANADIUM, TOTAL	20.9 J	20.7	33.7	29.2	19.9	18.9
ZINC, TOTAL	11.2	5.3	8.3	6.3	36.4	3

mg/kg - milligrams per kilogram
J - value is estimated
U - not detected
R - rejected

TABLE 4-5
SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA
INORGANIC ANALYTES

LOCATION	63-SB09-06	63-SB10-02	63-SB11-05	63-SB12-04	63-SB13-03	63-SB13-05
DATE SAMPLED	11/10/95	11/09/95	11/09/95	11/07/95	11/06/95	11/06/95
DEPTH	11-13'	3-5'	9-11'	7-9'	5-7'	9-11'
TOTAL METALS (mg/kg)						
ALUMINUM, TOTAL	9110	8710 J	11600 J	9230 J	12000 J	10000 J
ANTIMONY, TOTAL	2.9 UJ	4.1 U	5 U	2.3 UJ	2.9 U	2.2 U
ARSENIC, TOTAL	2.5 J	6.3	6.5	2.7	2.8	3.2
BARIUM, TOTAL	8.2	10.6	13.2	9.3	9.1	18.8
BERYLLIUM, TOTAL	0.17	0.18 U	0.21 U	0.17	0.08	0.15
CALCIUM, TOTAL	14.2	39.8	27.1 U	96.9 U	55.7	15.8
CHROMIUM, TOTAL	20.6	13.2	26.3	12.3	22.5	16.1
COBALT, TOTAL	1.2	0.6 U	0.73 U	0.57	0.59	1.1
COPPER, TOTAL	0.48 U	2.4	4.5	2.5	5.4 U	4.2 U
IRON, TOTAL	13500	5710	13900	3960 J	12700	3580
LEAD, TOTAL	7.6	7.2 J	8.2 J	7	8.2 J	10.9 J
MAGNESIUM, TOTAL	399	240	387	223	225	286
MANGANESE, TOTAL	10.9	5.5	5.9	4.1	5.4	11
NICKEL, TOTAL	2.5 J	43.7	2.4 U	4.4	18.6	1.8
POTASSIUM, TOTAL	946	468	740	509	496	691
SELENIUM, TOTAL	0.36 UJ	0.36 U	0.36	0.34 UJ	0.38	0.33 U
SILVER, TOTAL	0.76 U	0.51 U	0.62 U	0.61 U	0.74 U	0.57 U
SODIUM, TOTAL	38.5	18.4 U	27.7 U	20.4 U	28.1 U	84.6
THALLIUM, TOTAL	0.15 U	0.31 UJ	0.28 UJ	0.14 U	0.14 UJ	0.13 UJ
VANADIUM, TOTAL	29.7	14.4	36.8	15.5	48.2	17.8
ZINC, TOTAL	9.5	4.9	7.2	3 U	3.6 U	5.6

mg/kg - milligrams per kilogram
J - value is estimated
U - not detected
R - rejected

TABLE 4-5
SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA
INORGANIC ANALYTES

LOCATION	63-SB14-04	63-SB15-04	63-SB16-02	63-SB17-03	63-SB18-05	63-SB19-03
DATE SAMPLED	11/08/95	11/06/95	11/08/95	11/08/95	11/07/95	11/06/95
DEPTH	7-9'	7-9'	3-5'	5-7'	9-11'	5-7'
TOTAL METALS (mg/kg)						
ALUMINUM, TOTAL	6600	9600 J	9140	9020	6610 J	6280 J
ANTIMONY, TOTAL	2.7 UJ	2.6 U	3 UJ	2.9 J	2.6 UJ	2.5 UJ
ARSENIC, TOTAL	16	1.5	1	3.7	3.7	0.68
BARIUM, TOTAL	6.4	7	13.2	7.5	7.2	5.9
BERYLLIUM, TOTAL	0.06 U	0.06 U	0.07 U	0.21	0.12	0.06 U
CALCIUM, TOTAL	4	3.8 U	8.5	92.2	7.5 U	25.8 U
CHROMIUM, TOTAL	12.7	13.3	8.2	11.1	14	5.8
COBALT, TOTAL	0.47 UJ	0.47 U	0.53 UJ	0.48 UJ	0.47 U	0.45 U
COPPER, TOTAL	4.4 J	0.42 U	0.48 UJ	3.2 J	3.4	2.1
IRON, TOTAL	7320	2890	2320	2890	7640 J	807 J
LEAD, TOTAL	8.4	8.8 J	5.4	5.9	7.3	4.3
MAGNESIUM, TOTAL	158	190	191	184	157	104
MANGANESE, TOTAL	4.2	7.1	3.9	5.5	4.6	3.4
NICKEL, TOTAL	24.8	1.1	3.3	1.8	57	2.4
POTASSIUM, TOTAL	420	414	224	432	453	191 J
SELENIUM, TOTAL	0.72	0.38	0.36 U	0.28 U	0.34 UJ	0.29 UJ
SILVER, TOTAL	0.69 U	0.68 U	0.77 U	0.7 U	0.68 U	0.66 U
SODIUM, TOTAL	11.1 U	27.3 U	8.7 U	10 U	11.9 U	10.7 U
THALLIUM, TOTAL	0.14 UJ	0.13 UJ	0.14 U	0.11 U	0.14 U	0.12 U
VANADIUM, TOTAL	17.8	13.4	13.2	15.6	17.7	7.5
ZINC, TOTAL	2.9	3.6 U	3.9	2.9	2.9 U	2 U

mg/kg - milligrams per kilogram
J - value is estimated
U - not detected
R - rejected

TABLE 4-5
SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA
INORGANIC ANALYTES

LOCATION	63-SB20-01	63-SB21-03	63-SB22-03	63-SB23-03	63-SB24-03	63-SB25-03
DATE SAMPLED	11/09/95	11/08/95	11/07/95	11/07/95	11/07/95	11/06/95
DEPTH	1-3'	5-7'	5-7'	5-7'	5-7'	5-7'
TOTAL METALS (mg/kg)						
ALUMINUM, TOTAL	1140 J	6640	312	5490 J	3710 J	710 J
ANTIMONY, TOTAL	3.5 U	2.8 UJ	2.2 UJ	16.2 J	1.9 UJ	2.6 U
ARSENIC, TOTAL	0.4	2.6	0.3 U	6.3	0.71	0.31 U
BARIUM, TOTAL	3.4	7	4	1120	5.8	2.5
BERYLLIUM, TOTAL	0.15 U	0.07 U	0.05 U	0.11 U	0.05 U	0.06 U
CALCIUM, TOTAL	289	223	184	865 J	33.9 U	17.2
CHROMIUM, TOTAL	1.2	11.6	1.2	84.4	3.9	2.2
COBALT, TOTAL	0.5 U	0.75 J	0.4 UJ	14.9	0.34	0.56
COPPER, TOTAL	0.55	4 J	0.36 UJ	160	1.4	0.99 U
IRON, TOTAL	1040	4980 J	425 J	149000 J	1590 J	790
LEAD, TOTAL	6 J	6.8	3.7	1650	3.1	2 J
MAGNESIUM, TOTAL	32.7	195	27.3	103	63.3	18.1
MANGANESE, TOTAL	6.9	31.3 J	11.1 J	586	1.5	1.5
NICKEL, TOTAL	1.6 U	3.3	53.6	37.7	7.6	1.1
POTASSIUM, TOTAL	116 U	451	15.9 UJ	32.2 UJ	82.5 J	30.8
SELENIUM, TOTAL	0.25 U	0.31 U	0.28 U	0.27 UJ	0.3 UJ	0.29 U
SILVER, TOTAL	0.43 U	0.72 U	0.58 U	5.3	0.49 U	0.67 U
SODIUM, TOTAL	8.3 U	9.7	4.2 U	32.5	4.6 U	7.6 U
THALLIUM, TOTAL	0.22 UJ	0.12 U	0.11 U	0.54 UJ	0.12 U	0.12 UJ
VANADIUM, TOTAL	1.9	16.6	0.54	7.6	4.7	3.1
ZINC, TOTAL	7.1	16.1	6.5	1130	1.5 U	1.1 U

mg/kg - milligrams per kilogram
J - value is estimated
U - not detected
R - rejected

TABLE 4-5
SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA
INORGANIC ANALYTES

LOCATION	63-SB26-03	63-SB27-02	63-SB28-02	63-SB29-03	63-SB30-03	63-SB31-04
DATE SAMPLED	11/06/95	11/06/95	11/07/95	11/07/95	11/09/95	11/08/95
DEPTH	5-7'	3-5'	3-5'	5-7'	5-7'	7-9'
TOTAL METALS (mg/kg)						
ALUMINUM, TOTAL	6090 J	10400 J	6740	11000 J	5920	10000
ANTIMONY, TOTAL	2.9 UJ	3 U	2.2 UJ	2.6 UJ	2.8 UJ	2.9 UJ
ARSENIC, TOTAL	1.5	0.54	1.7	4.1	1	0.49
BARIUM, TOTAL	6.9	11.6	9.4	177	11	10.4
BERYLLIUM, TOTAL	0.07 U	0.07 U	0.05 U	0.1	0.07 U	0.26
CALCIUM, TOTAL	61.2 U	38.9	119	535 J	174	477
CHROMIUM, TOTAL	9.5	12	8.9	24	7.4	14
COBALT, TOTAL	0.52 U	0.72	0.44 J	4	0.5 UJ	0.52 UJ
COPPER, TOTAL	1.9	0.79 U	0.36 UJ	69.2	3.1 J	1.5 J
IRON, TOTAL	4180 J	1450	2950 J	40000 J	2050	3250
LEAD, TOTAL	4.8	7.2 J	7.1	182	6.1	4.3
MAGNESIUM, TOTAL	108	276	181	409	166	218
MANGANESE, TOTAL	2.9	6.1	6.5 J	202	10.5	4.3
NICKEL, TOTAL	76.1	1.7	2.2	12.8	1.8	1.7
POTASSIUM, TOTAL	165 J	580	315	737	279	457
SELENIUM, TOTAL	0.36 UJ	0.35 J	0.45	0.35 UJ	0.34 U	0.27 U
SILVER, TOTAL	0.75 U	0.79 U	0.57 U	1.8	0.72 U	0.76 U
SODIUM, TOTAL	5.9 U	25.8 U	8.9	61.9	19 U	12.5 U
THALLIUM, TOTAL	0.14 U	0.11 UJ	0.1 U	0.14 U	0.14 U	0.11 U
VANADIUM, TOTAL	11.3	13.2	13.6	22.1	11.2	27.7
ZINC, TOTAL	1.8 U	4.4 U	7.4	88.4	2.5	1.9

mg/kg - milligrams per kilogram
J - value is estimated
U - not detected
R - rejected

TABLE 4-5
SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA
INORGANIC ANALYTES

LOCATION	63-SB32-02	63-SB33-02	63-SB34-05	63-SB36-02	63-SB37-04	63-SB38-02
DATE SAMPLED	11/09/95	11/08/95	11/07/95	11/09/95	11/08/95	11/08/95
DEPTH	3-5'	3-5'	9-11'	3-5'	7-9'	3-5'
TOTAL METALS (mg/kg)						
ALUMINUM, TOTAL	9290	5350	7490	8010	7230	12100
ANTIMONY, TOTAL	2.9 UJ	2.7 UJ	3.2 UJ	3.6 J	3.1 UJ	3 UJ
ARSENIC, TOTAL	2.1	1.3	2.9	0.8	1.7	3
BARIUM, TOTAL	10.8	8.5	8.7	10.2	7.6	13.9
BERYLLIUM, TOTAL	0.07 U	0.07 U	0.08 U	0.06 U	0.08 U	0.29
CALCIUM, TOTAL	14.6	25.3 U	96.1	197	119	172
CHROMIUM, TOTAL	9.5	5.6	15.2	7.6	14.6	19.3
COBALT, TOTAL	0.52 UJ	0.49 UJ	0.57 UJ	0.46 UJ	0.56 UJ	0.54 UJ
COPPER, TOTAL	3.7 J	0.44 UJ	5.7 J	2.8 J	4.8 J	5.4 J
IRON, TOTAL	6080	3220 J	11600 J	5030	6960 J	10100
LEAD, TOTAL	12.4	4.3	8.3	3.6	7.3	7.9
MAGNESIUM, TOTAL	159	133	316	119	147	523
MANGANESE, TOTAL	4.4	3.5 J	6.3 J	3.5	2.4 J	10.4
NICKEL, TOTAL	3	5.7	37.5	2.1	1.5	4
POTASSIUM, TOTAL	229	84.6 J	536	148 U	374	705
SELENIUM, TOTAL	0.34 U	0.39	0.35 U	0.36 U	0.35 U	0.56
SILVER, TOTAL	0.75 U	0.71 U	0.82 U	0.67 U	0.82 U	0.78 U
SODIUM, TOTAL	9.4 U	5.1 U	12.8	8.6 U	10.1	20.2 U
THALLIUM, TOTAL	0.14 U	0.1 U	0.14 U	0.14 U	0.14 U	0.15 U
VANADIUM, TOTAL	13.5	9.5	19	13.1	22	22.1
ZINC, TOTAL	4.8	2.7 U	7.5	1.3	3.2 U	7

mg/kg - milligrams per kilogram
J - value is estimated
U - not detected
R - rejected

TABLE 4-5
SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA
INORGANIC ANALYTES

LOCATION	63-TW01-01	63-TW02-04	63-TW03-03	63-TW04-03	63-TW05-02	63-TW06-02
DATE SAMPLED	11/12/95	11/11/95	11/12/95	11/10/95	11/10/95	11/10/95
DEPTH	1-3'	7-9'	5-7'	5-7'	3-5'	3-5'
TOTAL METALS (mg/kg)						
ALUMINUM, TOTAL	1710	9790	9960	5610 J	3350 J	15100 J
ANTIMONY, TOTAL	2.7 R	3 R	3 R	4.3 U	3.5 U	4.4 U
ARSENIC, TOTAL	0.31 UJ	2.5 J	4.6 J	0.65 J	1.1 J	2.5
BARIUM, TOTAL	7.2	9.9	8.7	11.6	12.4	25.3
BERYLLIUM, TOTAL	0.07 UJ	0.07 UJ	0.07 UJ	0.18 U	0.15 U	0.19 U
CALCIUM, TOTAL	220	60.9	58.7	23.9 U	12.2 U	79
CHROMIUM, TOTAL	4.3 J	14.7 J	15.5 J	5.5	5.2	13.6
COBALT, TOTAL	0.48 U	0.53 U	0.54 U	0.93	0.51 U	0.96
COPPER, TOTAL	5.7	6.7	8.2	1.9	2.1	2.2
IRON, TOTAL	2580 J	7470 J	10400 J	2090	2290	4670
LEAD, TOTAL	3.2 J	6.7 J	7 J	3.9 J	6.3 J	11.2 J
MAGNESIUM, TOTAL	41.6 J	350	285	92.8	120	331
MANGANESE, TOTAL	16.6 J	8 J	6.2 J	3.1	4.1	6.6
NICKEL, TOTAL	0.8 U	0.98	8.4	7.9	5.3	4.2
POTASSIUM, TOTAL	40.9	663	620	145 U	142	253
SELENIUM, TOTAL	0.29 U	0.31 U	0.26 U	0.28 U	0.28 U	0.59
SILVER, TOTAL	0.69 U	0.77 U	0.79 U	0.53 U	0.44 U	0.55 U
SODIUM, TOTAL	9.6	17.3	7.6	11 U	14 U	26 U
THALLIUM, TOTAL	0.12 U	0.12 U	0.1 U	0.25 UJ	0.24 UJ	0.27 UJ
VANADIUM, TOTAL	3.3 J	20.2 J	19.9 J	7.6	7.4	16.7
ZINC, TOTAL	4.5	4.6	3.9	4.5 U	5.6	6.9

mg/kg - milligrams per kilogram
J - value is estimated
U - not detected
R - rejected

TABLE 4-5
SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA
INORGANIC ANALYTES

LOCATION	63-TW07-01		63-TW08-03	
DATE SAMPLED	11/11/95		11/09/95	
DEPTH	1-3'		5-7'	
TOTAL METALS (mg/kg)				
ALUMINUM, TOTAL	5470		10600	
ANTIMONY, TOTAL	2.2	R	3	UJ
ARSENIC, TOTAL	0.82	J	2.3	
BARIUM, TOTAL	18		13.4	
BERYLLIUM, TOTAL	0.05	UJ	0.29	
CALCIUM, TOTAL	191		130	
CHROMIUM, TOTAL	9.9	J	17.1	
COBALT, TOTAL	0.4	U	0.54	UJ
COPPER, TOTAL	19.7		5.8	J
IRON, TOTAL	7270	J	11000	
LEAD, TOTAL	13	J	7	
MAGNESIUM, TOTAL	185		427	
MANGANESE, TOTAL	17.9	J	8.7	
NICKEL, TOTAL	1.9		0.91	U
POTASSIUM, TOTAL	238		555	
SELENIUM, TOTAL	0.28	U	0.37	U
SILVER, TOTAL	0.58	U	0.79	U
SODIUM, TOTAL	9.5		19.5	U
THALLIUM, TOTAL	0.11	U	0.15	U
VANADIUM, TOTAL	14.7	J	19.1	
ZINC, TOTAL	146		6.2	

mg/kg - milligrams per kilogram
J - value is estimated
U - not detected
R - rejected

TABLE 4-6
GROUNDWATER - POSITIVE DETECTION SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA
ORGANIC COMPOUNDS

LOCATION	63-GW01-01	63-GW02-01	63-GW03-01	63-TW01-01	63-TW02-01	63-TW03-01
DATE SAMPLED	11/15/95	11/15/95	11/15/95	11/12/95	11/13/95	11/13/95
SEMIVOLATILES (ug/L)						
BIS(2-ETHYLHEXYL)PHTHALATE	1 J	9 U	11 U	12 U	11 U	10 U

ug/L - micrograms per liter
J - value is estimated
U - not detected

TABLE 4-6
GROUNDWATER - POSITIVE DETECTION SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA
ORGANIC COMPOUNDS

LOCATION	63-TW04-01	63-TW05-01	63-TW06-01	63-TW07-01	63-TW08-01
DATE SAMPLED	11/13/95	11/13/95	11/13/95	11/15/95	11/14/95
SEMIVOLATILES (ug/L)					
BIS(2-ETHYLHEXYL)PHTHALATE	11	10 U	11 U	11 U	11 U

ug/L - micrograms per liter
J - value is estimated
U - not detected

TABLE 4-7
GROUNDWATER - POSITIVE DETECTION SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA
INORGANIC ANALYTES

LOCATION	63-GW01-01	63-GW02-01	63-GW03-01	63-TW01-01	63-TW02-01	63-TW03-01
DATE SAMPLED	11/15/95	11/15/95	11/15/95	11/12/95	11/13/95	11/13/95
TOTAL ANALYTES (ug/L)						
ALUMINUM, TOTAL	213	325	175	98.4 U	763	2420
ARSENIC, TOTAL	1.6 U	1.8	1.6 U	1.6 U	1.6 U	1.6 U
BARIUM, TOTAL	18.3	461	78.3	47.8	81.7	53.2
CALCIUM, TOTAL	911 J	12400 J	5230 J	24900	3010	352
COBALT, TOTAL	3.4 U	3.4 U	11.9	3.4 U	8.3	5.1
IRON, TOTAL	93.6	24300	73.5	48.7 U	77.7 U	54.6 U
LEAD, TOTAL	1 U	1.7	1 U	1 U	1.3	2.2
MAGNESIUM, TOTAL	529	5800	2130	1280	3060	1010
MANGANESE, TOTAL	1.8	311	54	3.8	21.3	15.8
NICKEL, TOTAL	11.1 U	11.1 U	12.5	89.4	15.8	33.6
POTASSIUM, TOTAL	1430	8290	947	1300	1260	787 U
SODIUM, TOTAL	2850	4920	2830	2510	11800	7280
ZINC, TOTAL	6.7 U	20.8 U	48.2	4.9	11.8	41.4

ug/L - micrograms per liter
J - value is estimated
U - not detected

TABLE 4-7
GROUNDWATER - POSITIVE DETECTION SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA
INORGANIC ANALYTES

LOCATION	63-TW04-01	63-TW05-01	63-TW06-01	63-TW07-01	63-TW08-01
DATE SAMPLED	11/13/95	11/13/95	11/13/95	11/15/95	11/14/95
TOTAL ANALYTES (ug/L)					
ALUMINUM, TOTAL	287	2120	936	103 U	257
ARSENIC, TOTAL	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U
BARIUM, TOTAL	65.6	85.6	56.4	145	16.6
CALCIUM, TOTAL	1410	1330 J	3450 J	6490 J	1520 J
COBALT, TOTAL	3.4 U	4.8	3.4 U	5.1	3.4 U
IRON, TOTAL	550	24300	248	2540	88.2
LEAD, TOTAL	1 U	9.4	1.2	1 U	1 U
MAGNESIUM, TOTAL	692	590	1220	2560	564
MANGANESE, TOTAL	23.7	191	5.1	181	3.8
NICKEL, TOTAL	83.2	74.2	15.5	57.4	44.5
POTASSIUM, TOTAL	787 U	1210	787 U	2670	787 U
SODIUM, TOTAL	4750	2300	7120	5140	3710
ZINC, TOTAL	3.6 U	183	9.9 U	17100	4.4 U

ug/L - micrograms per liter
J - value is estimated
U - not detected

TABLE 4-8
SURFACE WATER - POSITIVE DETECTION SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA
ORGANIC COMPOUNDS

LOCATION	63-SW01	63-SW02	63-SW03	63-SW04	63-SW05
DATE SAMPLED	11/10/95	11/10/95	11/10/95	11/10/95	11/10/95
VOLATILES (ug/L)					
ACETONE	10 UJ	10 UJ	10 UJ	11 J	10 UJ
SEMIVOLATILES (ug/L)					
BIS(2-ETHYLHEXYL)PHTHALATE	100	10 U	10 U	9 U	10 U

ug/L - micrograms per liter
J - value is estimated
U - not detected

TABLE 4-9
SURFACE WATER - POSITIVE DETECTION SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA
INORGANIC ANALYTES

LOCATION	63-SW01	63-SW02	63-SW03	63-SW04	63-SW05
DATE SAMPLED	11/10/95	11/10/95	11/10/95	11/10/95	11/10/95
TOTAL ANALYTES (ug/L)					
ALUMINUM, TOTAL	627	650	653	602	688
BARIUM, TOTAL	22.1	24.6	26.4	26	23.7
CALCIUM, TOTAL	1780	1900	1960	1940	1740
IRON, TOTAL	292	309	390	615	834
LEAD, TOTAL	1 U	1	2.2	1.2	1.6
MAGNESIUM, TOTAL	678	710	713	739	809
MANGANESE, TOTAL	4.7	6.2	9.2	9.4	10
SODIUM, TOTAL	4250	4370	4480	4420	4290
ZINC, TOTAL	6.6	5.5	22.6	8.4	7.8

ug/L - micrograms per liter
U - not detected

TABLE 4-10
SEDIMENT - POSITIVE DETECTION SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA
ORGANIC COMPOUNDS

LOCATION	63-SD01-01	63-SD02-01	63-SD03-01	63-SD04-01	63-SD05-01
DATE SAMPLED	11/11/95	11/11/95	11/11/95	11/11/95	11/11/95
DEPTH	0-6"	0-6"	0-6"	0-6"	0-6"
PESTICIDE/PCBS (ug/kg)					
4,4'-DDE	4.9 U	5 UJ	4.3 UJ	4.2 J	4.2 UJ
4,4'-DDD	4.9 U	5 UJ	2.6 J	11 J	4.2 UJ
4,4'-DDT	4.9 U	5 UJ	4.3 UJ	1.6 J	4.2 UJ
ALPHA-CHLORDANE	2.4 U	2.5 UJ	2.2 UJ	4.7 J	2.1 UJ
GAMMA-CHLORDANE	2.4 U	2.5 UJ	2.2 UJ	6.2 J	2.1 UJ

ug/kg - micrograms per kilogram
J - value is estimated
U - not detected

TABLE 4-11
SEDIMENT - POSITIVE DETECTION SUMMARY
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA
INORGANIC ANALYTES

LOCATION	63-SD01-01	63-SD02-01	63-SD03-01	63-SD04-01	63-SD05-01
DATE SAMPLED	11/11/95	11/11/95	11/11/95	11/11/95	11/11/95
DEPTH	0-6"	0-6"	0-6"	0-6"	0-6"
TOTAL METALS (mg/kg)					
ALUMINUM, TOTAL	890	1270	5910	7050	1240
ARSENIC, TOTAL	0.35 UJ	0.39 UJ	0.29 J	0.63 J	0.33 UJ
BARIUM, TOTAL	9.3	8.9	15.1	19.6	3.8
BERYLLIUM, TOTAL	0.06 UJ	0.06 UJ	0.05 U	0.14 J	0.07 UJ
CALCIUM, TOTAL	66	118	106	178	49.9
CHROMIUM, TOTAL	0.9 U	1.4 J	5.7 J	8.1 J	1.7 J
COPPER, TOTAL	4	2.8	5.7	6.9	0.47 U
IRON, TOTAL	84.9 J	174 J	1260 J	2050 J	419 J
LEAD, TOTAL	3.7 J	11.9 J	5.9 J	13.7 J	3.2 J
MAGNESIUM, TOTAL	11.3 J	32.9 J	170	259	39.6 J
MANGANESE, TOTAL	1.6 J	1.7 J	4.1 J	7.5 J	3 J
NICKEL, TOTAL	0.72 U	0.77 U	1.9	0.97 U	0.88 U
POTASSIUM, TOTAL	17.1 U	27.4	186	367	45.4
SODIUM, TOTAL	7.6	9.8	12.9	12.5	7.8
VANADIUM, TOTAL	1.2 J	1.5 J	7.7 J	12.4 J	1.5 J
ZINC, TOTAL	0.94	0.92	5.4	6.7	1

mg/kg - milligrams per kilogram
J - value is estimated
U - not detected

SECTION 4.0 FIGURES

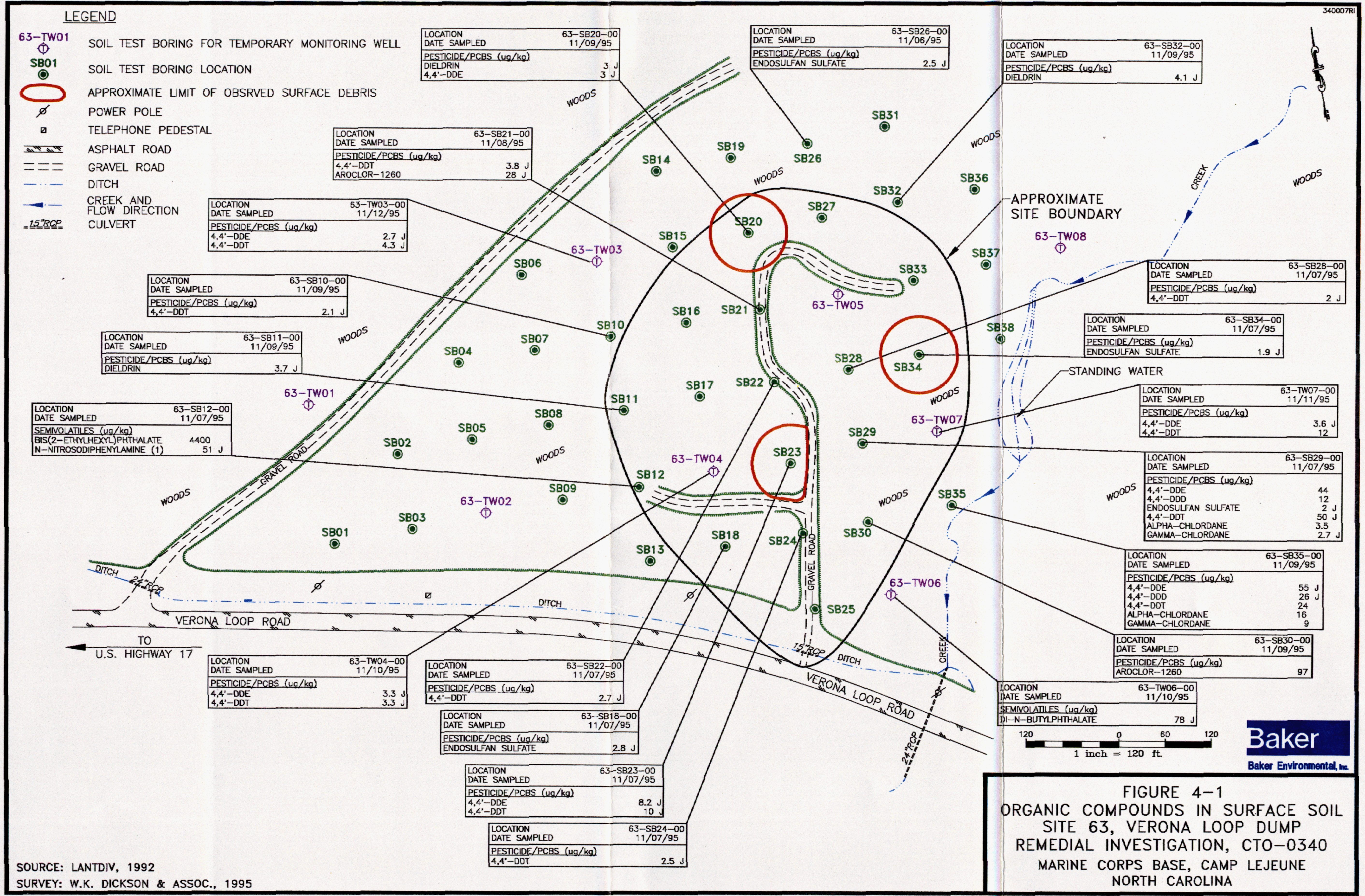


FIGURE 4-1
ORGANIC COMPOUNDS IN SURFACE SOIL
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01708N22Y

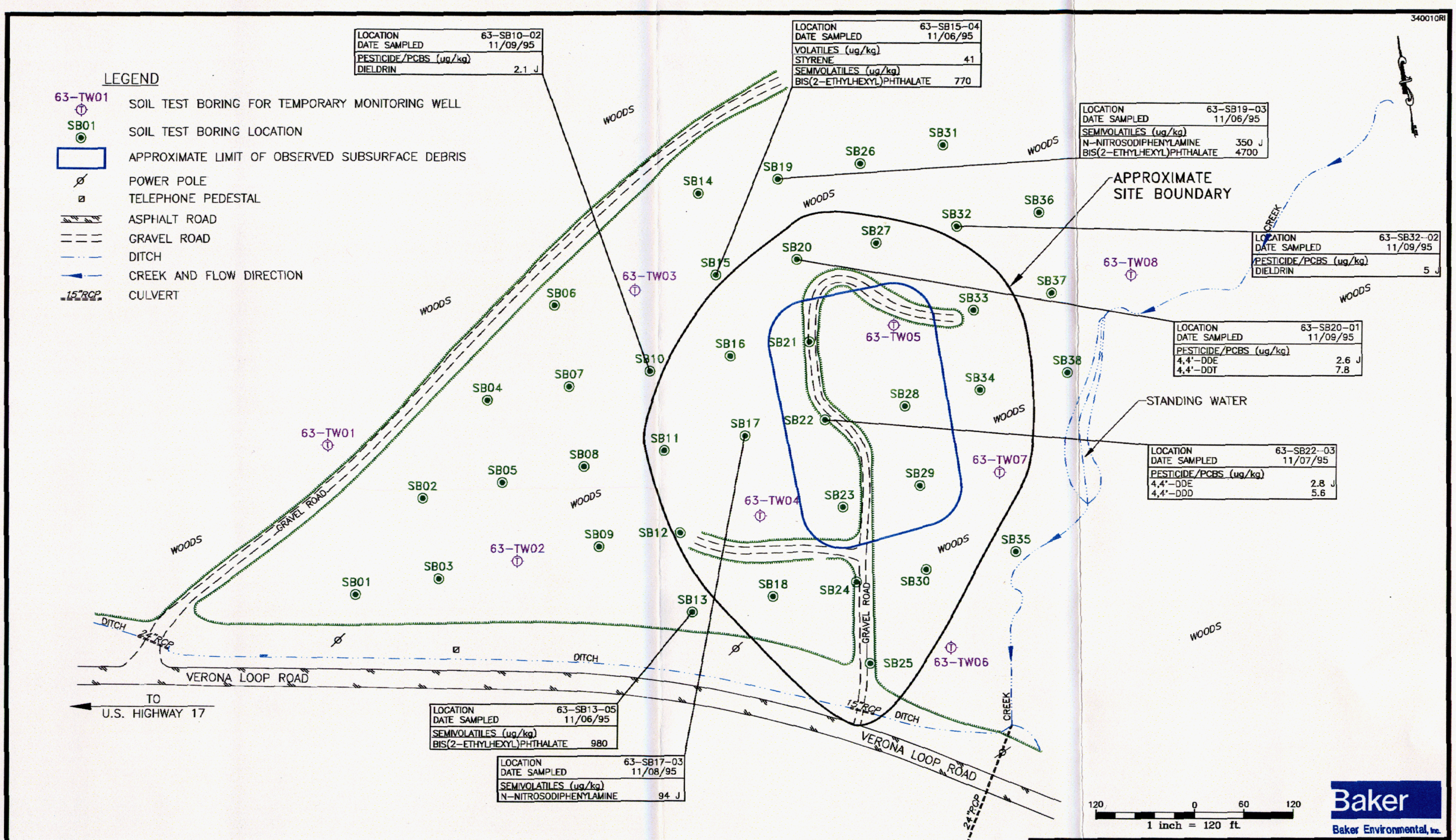


FIGURE 4-2
ORGANIC COMPOUNDS IN SUBSURFACE SOIL
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

SOURCE: LANTDIV, 1992
SURVEY: W.K. DICKSON & ASSOC., 1995

01708N23Y

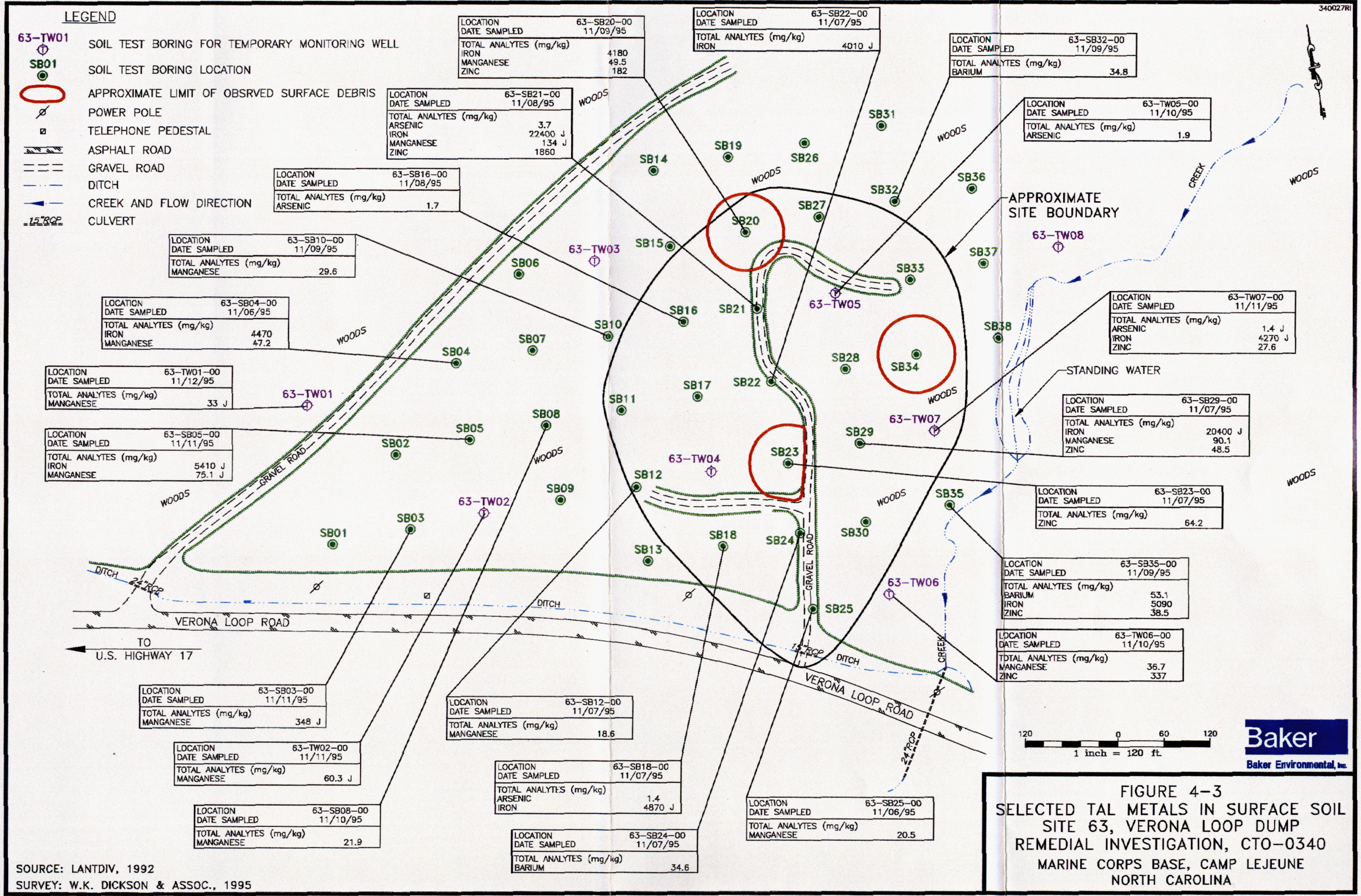
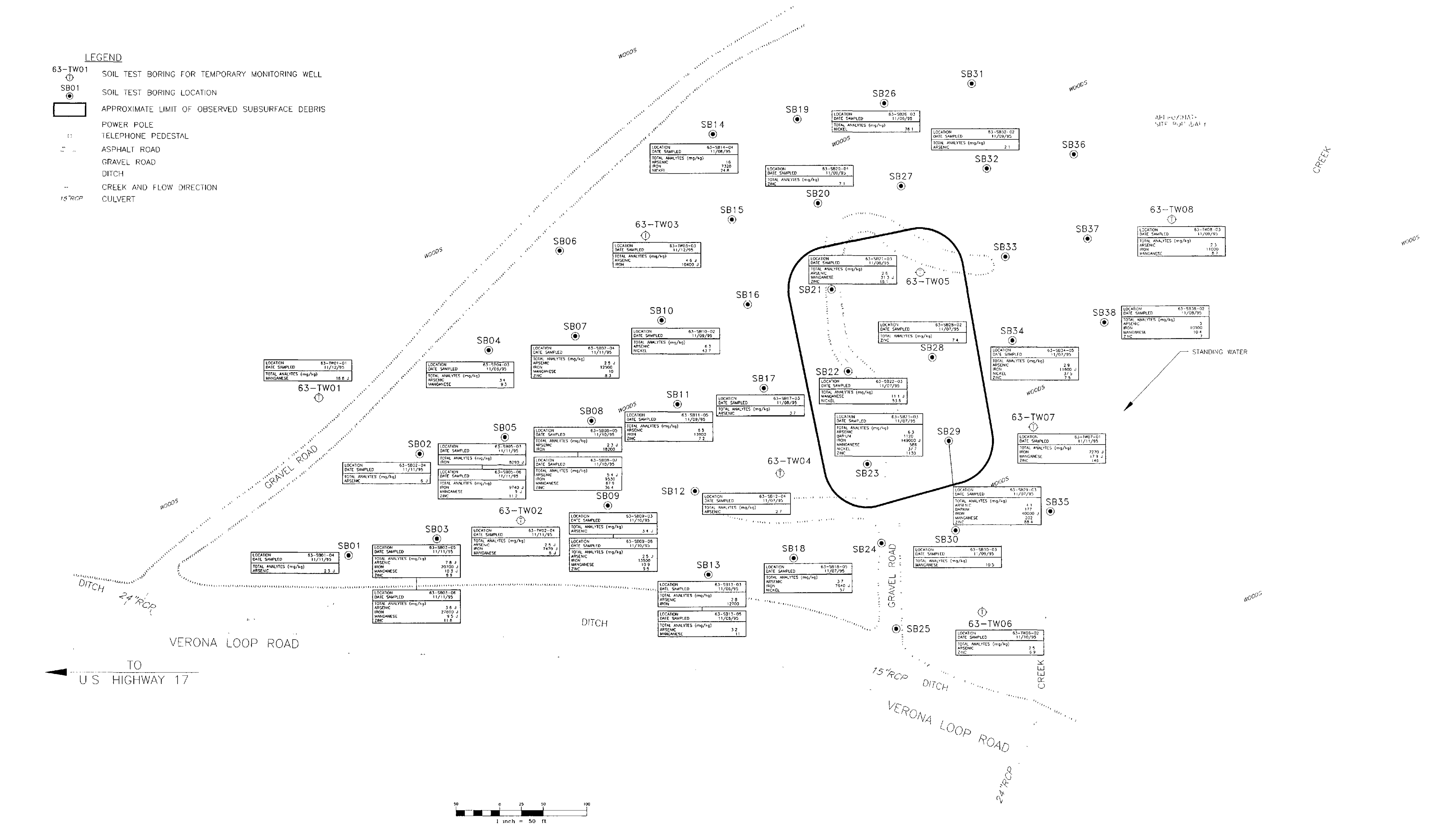


FIGURE 4-3
SELECTED TAL METALS IN SURFACE SOIL
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01708N24Y



REVISIONS		
	DRAWN	REL
	REVIEWED	TFT
	S.O.#	62470-340
	CADD#	340028RI

NOTES: DEPICTED METAL CONCENTRATIONS ARE THOSE WHICH HAVE EITHER EXCEEDED USEPA REGION III SOIL CRITERIA PROTECTIVE OF GROUNDWATER OR ARE A PRIORITY POLLUTANT METAL THAT HAS CONTRIBUTED TO THE HUMAN HEALTH RISK AND WAS DETECTED ABOVE BASE-SPECIFIC BACKGROUND LEVELS.

NORTH

REMEDIAL INVESTIGATION, CTO-0340
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

SELECTED TAL METALS IN SUBSURFACE SOIL
SITE 63, VERONA LOOP DUMP

SCALE 1" = 50'

DATE APRIL 1996

FIGURE No
4-4

01708N25X

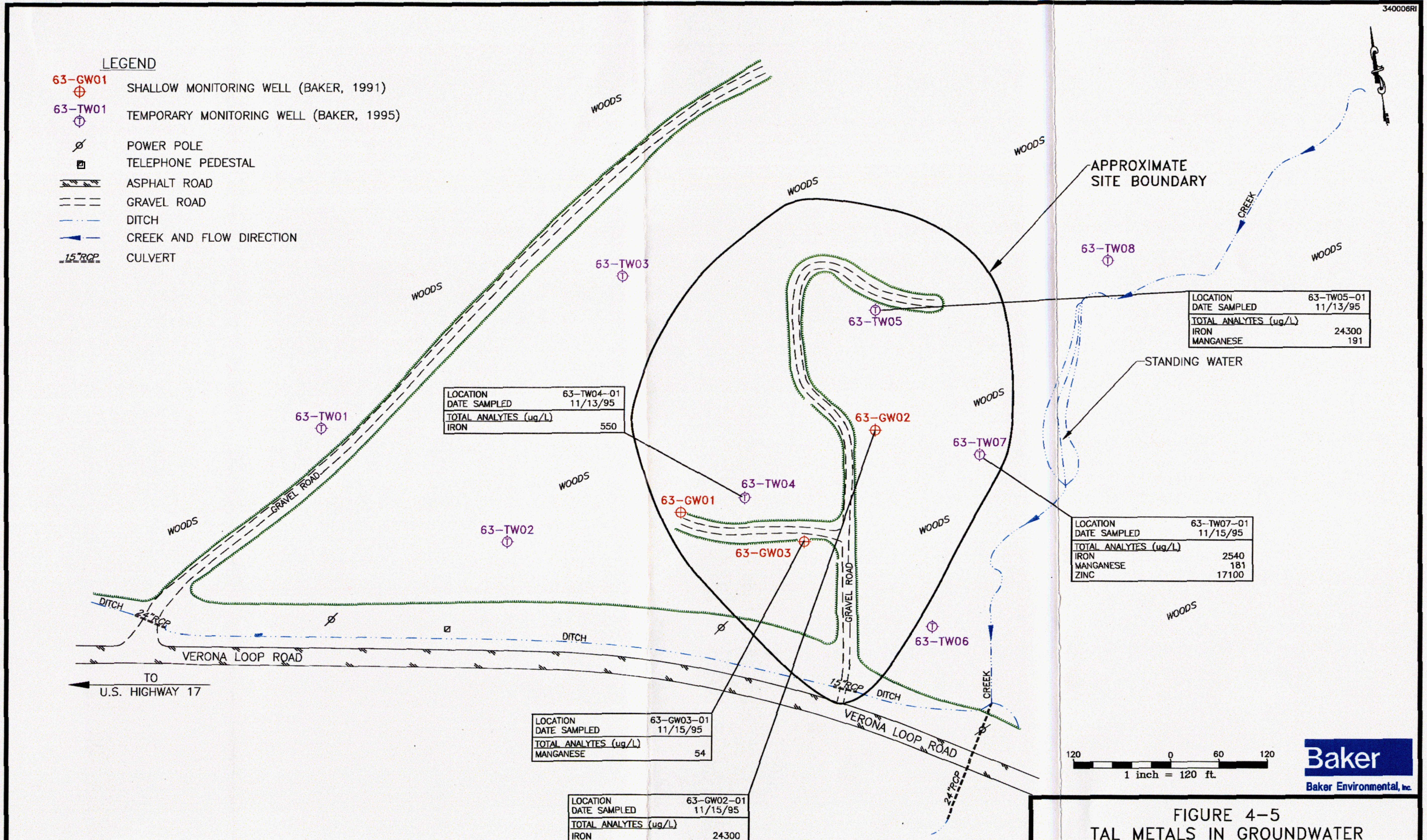


FIGURE 4-5
TAL METALS IN GROUNDWATER
ABOVE SCREENING STANDARDS
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

SOURCE: LANTDIV, 1992
SURVEY: W.K. DICKSON & ASSOC., 1995

01708N26Y

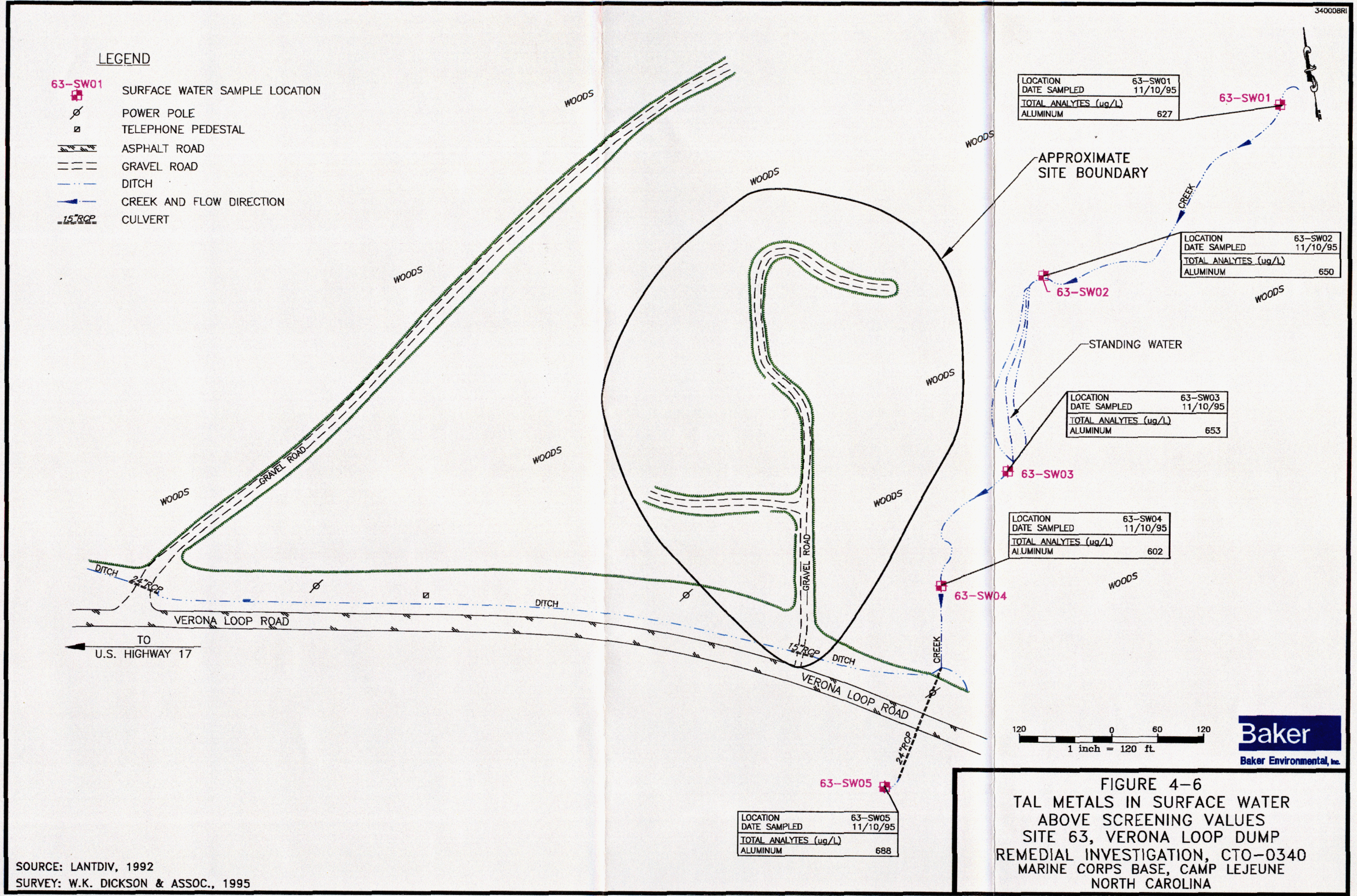
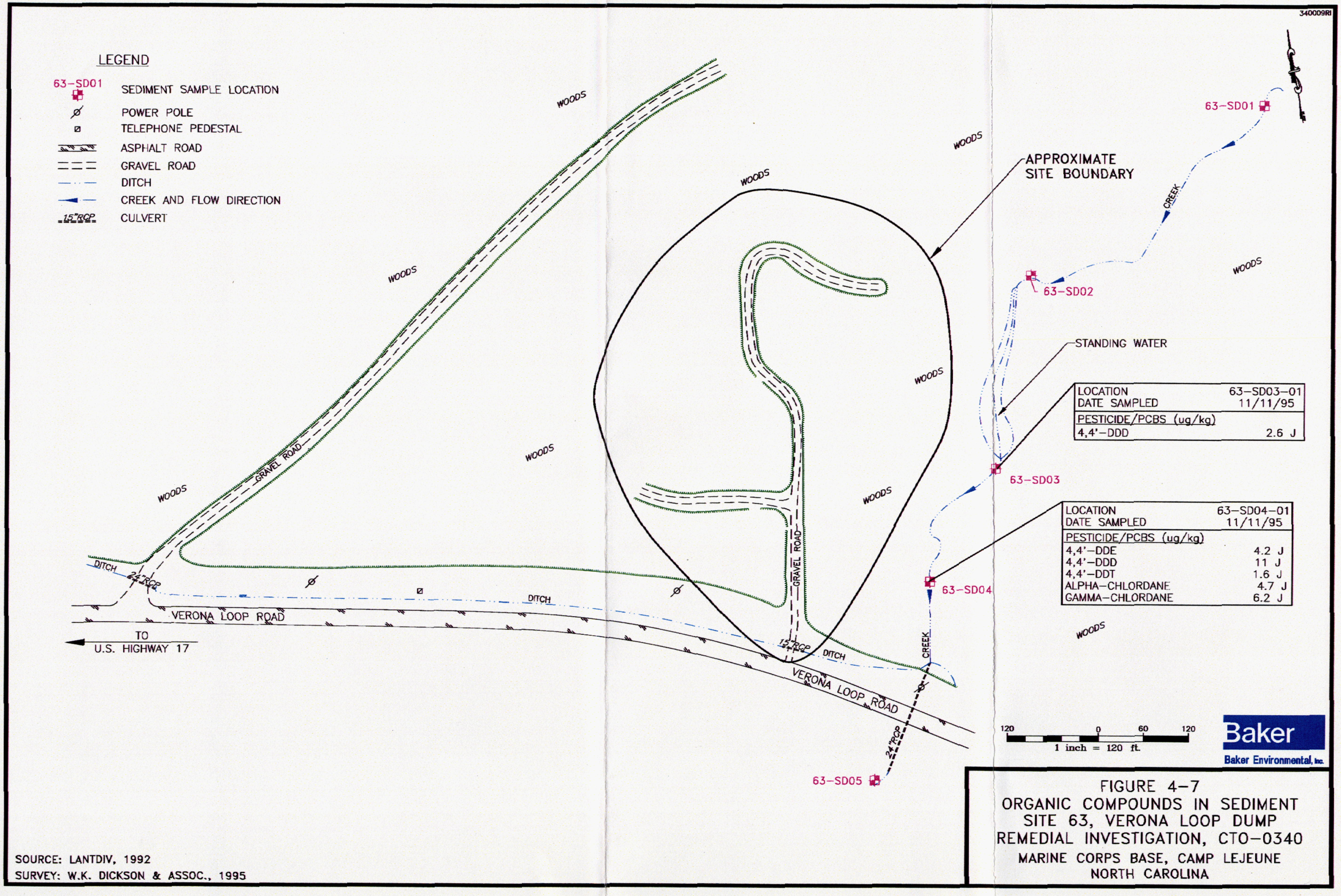


FIGURE 4-6
TAL METALS IN SURFACE WATER ABOVE SCREENING VALUES
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01708N27Y



LOCATION	63-SD03-01
DATE SAMPLED	11/11/95
PESTICIDE/PCBS (ug/kg)	
4,4'-DDD	2.6 J

LOCATION	63-SD04-01
DATE SAMPLED	11/11/95
PESTICIDE/PCBS (ug/kg)	
4,4'-DDE	4.2 J
4,4'-DDD	11 J
4,4'-DDT	1.6 J
ALPHA-CHLORDANE	4.7 J
GAMMA-CHLORDANE	6.2 J

FIGURE 4-7
ORGANIC COMPOUNDS IN SEDIMENT
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

5.0 CONTAMINANT FATE AND TRANSPORT

The potential for a contaminant to migrate and persist in an environmental medium is critical when evaluating the potential for a compound to elicit an adverse human health or ecological effect. The environmental mobility of a compound is influenced by its physical and chemical properties, the physical characteristics of the site, and site chemistry. This section presents a discussion of the various physical and chemical properties of significant contaminants in Site 63 media and their fate and transport in the environment.

5.1 Chemical and Physical Properties Impacting Fate and Transport

Table 5-1 presents the physical and chemical properties associated with the organic compounds detected during this investigation. These properties determine the inherent environmental mobility and fate of a contaminant. The properties of interest include:

- Vapor pressure
- Water solubility
- Octanol/water partition coefficient
- Organic carbon adsorption coefficient (sediment partition)
- Specific gravity
- Henry's Law constant

The following is a discussion of the environmental significance of each of these properties using hypothetical examples not related to Site 63:

Vapor pressure provides an indication of the rate at which a chemical may volatilize. It is of primary significance at environmental interfaces such as surface soil/air and surface water/air. For example, vapor pressures for monocyclic aromatics are generally higher than vapor pressures for polynuclear aromatic hydrocarbons (PAHs). Contaminants with higher vapor pressures will enter the atmosphere at a quicker rate than the contaminants with low vapor pressures.

The rate at which a contaminant is leached from soil by infiltrating precipitation is proportional to its water solubility. More soluble contaminants are usually more readily leached than less soluble contaminants. For example, water solubilities indicate that volatile organic contaminants are usually several orders-of-magnitude more soluble than PAHs. Consequently, highly soluble compounds will go into solution faster and possibly in greater concentrations than less soluble compounds. The solubility of a specific compound is dependent on the chemistry of the groundwater and aquifer material. Factors such as groundwater pH, Eh (redox potential), temperature, and the presence of other compounds can affect solubility.

The octanol/water partition coefficient (K_{ow}) is the ratio of the chemical concentration in octanol divided by the concentration in water. The octanol/water partition coefficient has been shown to correlate well with bioconcentration factors in aquatic organisms and adsorption to soil or sediment. Specifically, a linear relationship between octanol/water partition coefficients and the uptake of chemicals by fatty tissues of animal and human receptors (the bioconcentration factor - BCF) has been established (Lyman et al., 1982). The coefficient is also useful in characterizing the sorption of compounds by organic soils where experimental values are not available.

The organic carbon adsorption coefficient (K_{oc}) indicates the tendency of a chemical to adhere to organic carbon in soil particles. The solubility of a chemical in water is inversely proportional to the K_{oc}. Contaminants with high soil/sediment adsorption coefficients generally have low water solubilities. For example, contaminants such as PAHs are relatively immobile in the environment, are preferentially bound to the soil, and therefore have a higher K_{oc} value. These compounds are not subject to aqueous transport to the extent of compounds with higher water solubilities. Mechanical activities (e.g., erosion) and the physical characteristics of surface soils may, however, increase the mobility of these bound soil contaminants.

Specific gravity is the ratio of a given volume of pure chemical at a given temperature to the weight of the same volume of water at a given temperature. Its primary use is to determine whether a contaminant will have a tendency to "float" or "sink" as an immiscible liquid in water if its concentration exceeds its corresponding water solubility.

Vapor pressure and water solubility are of use in determining volatilization rates from surface water bodies and from groundwater. These two parameters can be used to estimate an equilibrium concentration of a contaminant in the water phase and in the air directly above the water. This relationship is expressed as Henry's Law Constant.

A quantitative assessment of mobility has been developed that uses water solubility (S), vapor pressure (VP), and organic carbon partition coefficient (K_{oc}) (Laskowski, 1983). This value is referred to as the Mobility Index (MI). It is defined as:

$$MI = \log((S*VP)/K_{oc})$$

A scale to evaluate MI as presented by Ford and Gurba (1984) is:

Relative MI	Mobility Description
> 5	extremely mobile
0 to 5	very mobile
-5 to 0	slightly mobile
-10 to -5	immobile
< -10	very immobile

Relative mobility indices have been determined for most of the organic contaminants, based on available information. As illustrated on Table 5-1, the SVOCs are slightly mobile, while pesticides and PCBs are immobile to very immobile.

5.2 Contaminant Transport Pathways

Based on the evaluation of existing conditions at Site 63, the following potential contaminant transport pathways have been identified.

- Windblown dust
- Erosion of soil due to surface water runoff
- Leaching of sediment contaminants to surface water
- Migration of contaminants in surface water
- Leaching of soil contaminants to groundwater

- Migration of contaminants in groundwater

Contaminant concentrations may be affected by one or more mechanisms during transport. Contaminants may be physically transformed by volatilization or precipitation. Contaminants may be chemically transformed through photolysis, hydrolysis, or oxidation/reduction. Contaminants may be biologically transformed by biodegradation. Additionally, contaminants may accumulate in one or more media.

The paragraphs which follow describe the potential transport pathways listed above with respect to significant compound concentrations. Significant compound concentrations refer to those compounds discussed in Section 4.0 frequently occurring above comparisons criteria. Specific fate and transport mechanisms are discussed in Section 5.3.

5.2.1 Windblown Dust

As shown on Figure 4-1 and 4-3, the predominant compounds detected in surface soils are pesticides and metals. Pesticides, and in some cases certain metals, tend to be bound to soil particles. Physical movement of the soil is the only migration pathway available to transport these compounds.

Wind can erode exposed soil. This effect is influenced by wind velocity, soil particle size and density and cohesion, moisture content, and vegetative cover. This is a relatively insignificant migration pathway because at least 90 percent of the surface area at Site 63 is covered by vegetation and vehicle traffic is negligible. Vegetative cover may mitigate the generation of dust and movement of soil particles.

5.2.2 Erosion of Soil Due to Surface Water Runoff

As shown on Figures 4-1 and 4-3, the predominant compounds detected in surface soils are pesticides and metals. Pesticides, and in some cases certain metals, tend to be bound to soil particles. Physical movement of the soil is the only migration pathway available to transport these compounds and analytes.

Water can erode soil particles during precipitation. Soil particle size, density, cohesion, and vegetative cover may influence the ability of water to erode soil. The eastern portion of the site slopes toward an unnamed tributary, creating a potential for soil erosion. Soil erosion is a relatively insignificant migration pathway, however, because of dense vegetative cover on the slopes.

5.2.3 Leaching of Sediment Contaminants to Surface Water

At Site 63, there is one surface water body of concern; an unnamed tributary to Mill Run. The only compounds detected in sediment samples at significant concentrations were pesticides (refer to Figure 4-7).

When in contact with surface water, contaminants attached to sediment particles can disassociate from the particle into surface water. This is primarily influenced by the physical and chemical properties of the contaminant (i.e., water solubility, K_{oc}) and the physical and chemical properties of the sediment particle (i.e., grain size). This is a relatively important pathway because the stream bed sediments are in direct contact with the surface water.

5.2.4 Migration of Contaminants in Surface Water

Only metals were detected in surface water from the unnamed tributary with any frequency, and only aluminum was present at concentrations above screening criteria (refer to Figure 4-6). Typically, a considerable fraction of metals in surface water is associated with suspended particles. The extent of this association varies greatly with the potential contaminant, the properties of sediment particles, and surface water chemistry. Contaminants in surface water carried on particles will settle in areas of active sedimentation and will be deposited in the sediments. Metals may be released again through microbial activity and changes in various physical and chemical factors, including pH and Eh. Controls for dissolved metals in surface water are dependent upon the specific metal and factors such as pH, Eh, and temperature. The migration of contaminants in surface water is a relatively insignificant migration pathway because of the low and intermittent flow rate of the stream. Flow rates fast enough to transport particles, the significant source of metals, are infrequent and of a short duration.

5.2.5 Leaching of Soil Contaminants to Groundwater

Pesticides were detected in 16 surface soils samples from locations within the suspected disposal portion of the study area. Pesticides were detected in four shallow subsurface soils samples, also from locations in and around the approximate site boundary. Metals were detected in the surface and subsurface soil samples. However, only a few of these metals occur at significant concentrations in soils (refer to Figures 4-3 and 4-4).

Contaminants that adhere to soil particles or have accumulated in soil pore spaces can leach and migrate vertically to the groundwater as a result of infiltration and precipitation. The rate and extent of leaching is influenced by the depth to the water table, amount of precipitation, rate of infiltration, and the physical and chemical properties of the soil and contaminant. This is a relatively important pathway because of the direct contact between infiltrating water and soil particles. However, the data show that pesticides are not leaching to groundwater. Additionally, the ability of metals to leach from soil to groundwater is strongly dependent on the specific metal and geochemical conditions.

5.2.6 Migration of Contaminants in Groundwater

The presence of organics and metals in soil creates the potential for a relatively important pathway of migration in groundwater. However, no organic compounds have been detected in groundwater. Thus, a detailed discussion of organic compound transport mechanisms is not warranted. Metals have been detected in both soils and groundwater. Fate and transport is primarily a function of specific metal ion species and aquifer conditions. A general discussion relating the occurrence of metals in the environment to natural conditions or the presence of metal debris is presented in Section 5.3.4.

5.3 <u>Fate and Transport Summary</u>

The paragraphs which follow summarize the site-specific fate and transport data for contaminants detected in media collected at Site 63. Analysis of the analytical data with respect to hydrogeologic conditions does not reveal any pattern or trend to suggest that identified contaminants are related or migrating from Site 63 to the surrounding environment.

5.3.1 Volatile Organic Compounds

VOCs were detected in a very limited number of samples at low concentrations. VOC contamination is not a concern at Site 63.

5.3.2 Semivolatile Organic Compounds

SVOCs were detected in a very limited number of samples at generally low concentrations; therefore, SVOC contamination is not a concern at Site 63.

5.3.3 Pesticides

Pesticides have been detected in 16 surface and subsurface soil sample locations at Site 63. Pesticides have also been detected in two sediment samples in an unnamed tributary adjacent to Site 63. The pattern of distribution and concentration suggests routine application for insect control rather than product disposal may be the source of pesticides. Table 5-1 shows that pesticides are immobile, mainly due to their affinity for soil surfaces. Pesticides appear to have migrated to stream sediment possibly through soil erosion and/or direct deposition from pesticide application at mosquito breeding areas. If migration is due to erosion, pesticides may continue to accumulate in sediment as erosion of soils continues. Routine pesticide application is no longer practiced. Therefore, the rate of accumulation should diminish with time due to the diminishing availability of pesticides.

5.3.4 Metals

Metal analytes may be present due to disposal activity or natural aquifer chemistry. The transport of metal analytes in groundwater is heavily dependent on aquifer chemistry and the metal species present. Due to the scope of this report, a quantitative analysis of metal fate and transport is not possible. If the presence of metal analytes was determined to be a significant risk, then a quantitative analysis of fate and transport would be performed through additional sampling that better defines metal speciation and aquifer chemistry. However, a qualitative fate and transport analysis may be made through the correlation between the presence of metal debris and metal analytes in various media and through generic studies of the presence of metals in various environmental media.

There appears to be no correlation between the presence of surface metal debris and elevated concentrations of metal analytes in surface soils. Figure 4-3 illustrates that the highest concentrations of select metals in surface soil do not correspond with areas of surface debris.

There appears to be some correlation between the presence of subsurface metal debris and elevated concentrations of metals in subsurface soil. The highest observed concentrations of iron, manganese, and zinc occurred in the 5- to 7-foot sample depth interval from boring 63-SB23. According to the log for this boring (refer to Appendix A), the sample contained rusty metal debris. In contrast, some of the highest concentrations of iron and manganese were observed in subsurface soil samples outside the area of observed debris. These two points suggest that the presence of metals in subsurface soils may be due to either metal debris, the natural chemistry, or both.

There appears to be no correlation between elevated metals in subsurface soils and groundwater. This conclusion is based on two factors: 1) the distribution of iron, manganese, and zinc in groundwater relative to their distribution in subsurface soil; and 2) most occurrences of metals in groundwater are within the range of natural concentrations. The following paragraphs discuss each factor separately.

As noted in Section 4.3, several metals occur in subsurface soils at significant concentrations. However, only iron, manganese, and zinc were detected in groundwater at significant concentrations. The distribution of elevated concentrations of iron, manganese, and zinc in groundwater (refer to Figure 4-5) does not necessarily correspond to elevated concentrations observed in subsurface soils (refer to Figure 4-4). Iron, manganese, and zinc appear in relatively low concentrations in groundwater samples from wells located in the area west of the site boundary. However, subsurface soils samples from this area exhibited some of the highest concentrations of metals. Metals would be expected in samples from these wells assuming similar aquifer conditions. The pH is an indication that aquifer conditions are similar; the groundwater pH is between 4.0 and 6.0 S.U. across the site, with no apparent trend.

The observed concentrations of iron, manganese, and zinc are generally within the limits of natural occurrence. According to a study of chemical characteristics of natural waters (Hem, 1992), iron can occur in groundwater at levels as high as 50 mg/L, given certain conditions, and manganese can occur in groundwater above 1.0 mg/L. Iron can occur in groundwater from the oxidation of ferrous sulfides. Hem also indicates that manganese sulfate could be an important control for the presence of manganese in natural water. Metallic sulfides/sulfates are common in sedimentary and igneous rocks or soils/sediments with those source rocks. Manganese can also dissolve into groundwater from manganese oxide coatings on soil/sediment particles. Small amounts of manganese are commonly present in limestone and dolomite, substituting for calcium. Partially cemented limestone and calcareous sediments are common throughout the MCB, Camp Lejeune area. A study of trace elements in the Newport River Estuary (approximately 40 miles north of MCB, Camp Lejeune) found iron, manganese, and zinc to be naturally occurring in sediment extract and surface water samples (Cross, et al., 1970).

The surface water and sediment in the unnamed tributary does not appear to be affected by metal debris observed at the site. Aluminum was detected above screening criteria in the surface water, but as discussed in Section 4.4.3 does not appear to be attributable to human activity at Site 63.

Regardless of the source, metals in groundwater do not appear to be very mobile within Site 63. Figure 4-5 shows TAL metals above screening standards in groundwater samples from a few wells within the approximate site boundary. However, none of these metals appear in significant concentrations in downgradient receptors, such as the intermittent stream and temporary wells 63-TW01, 63-TW02, and 63-TW03.

Several metal analytes were detected above tap water risk-based concentrations (RBCs) in several surficial aquifer groundwater samples. No organic compounds were detected above RBCs. The analytes included aluminum, arsenic, barium, cobalt, iron, lead, manganese, nickel, and zinc. It appears unlikely that these analytes will migrate to the Castle Hayne Aquifer and affect drinking water wells. Two factors support this conclusion:

1. The distribution of metals in shallow groundwater suggests that the migration of these analytes is limited.

2. The nearest water supply well is located approximately two miles to the north of Site 63 and is in a different regional groundwater flow system. According to Cardinell, et. al., 1993, groundwater from the Castle Hayne Aquifer discharges to the New River and its major tributaries. Southwest Creek would intercept groundwater from the Castle Hayne aquifer originating from the Site 63 area before it would reach the nearest water supply well.

5.4 References

Cross, Ford A., Duke, Thomas W., and James N. Willis. 1970. "Biogeochemistry of Trace Elements in a Coastal Plain Estuary: Distribution of Manganese, Iron, and Zinc in Sediments, Water, and Polychaetous Worms." Chesapeake Science. Vol. 11, No. 4, 221-234. December 1970.

Environmental Science and Engineering, Incorporated (ESE). 1988. Characterization Step Report for Hadnot Point Industrial Area, Marine Corps Base, Camp Lejeune, North Carolina. Prepared for the Department of the Navy, Naval Facilities Engineering Command, Atlantic Division, Norfolk, Virginia. ESE Project No. 49-02036-0150.

Fetter, C.W. 1986. Applied Hydrogeology. Charles E. Merrill Publishing Co., Columbus, Ohio.

Ford and Gruba. 1984. Methods of Determining Relative Contaminant Mobilities and Migration Pathways Using Physical-Chemical Data.

Hem. 1992. Study of Interpretation of the Chemical Characteristics of Natural Waters. USGS Water-Supply Paper 22254.

Howard, Philip H. 1989. Handbook of Environmental Fate and Exposure Data for Organic Chemicals - Pesticides. Lewis Publishers. Chelsea, Michigan.

Howard, Philip H. 1990. Handbook of Environmental Fate and Exposure Data for Organic Chemicals - Large Production and Priority Pollutants. Lewis Publishers. Chelsea, Michigan.

Howard, Philip H. 1991. Handbook of Environmental Fate and Exposure Data for Organic Chemicals - Solvents. Lewis Publishers. Chelsea, Michigan.

Laskowski, D.A., Goring, C.A., McCall, P.J., and R.L. Swann. 1983. "Terrestrial Environment in Environmental Risk Analysis for Chemicals." Environmental Risk Analysis for Chemicals. R.A. Conways, ed., Van Nostrand Reinhold Company, New York, New York.

Lyman, W.J., Rechl, W.F., and D.H. Rosenblatt. 1982. Handbook of Chemical Property Estimation Methods. McGraw-Hill, Inc., New York.

Montgomery, J.H. and L.M. Welkon. 1990. Groundwater Chemicals Desk Reference. Lewis Publishers, Inc. Chelsea, Michigan.

Sax N. and R. Lewis. 1987. Hawley's Condensed Chemical Dictionary. Van Norstrand Reinhold, New York.

Superfund Chemical Data Matrix (SCDM). 1991. United States Environmental Protection Agency Hazardous Site Evaluation Division. December 1991.

Swartbaugh, et al. "Remediating Sites Contaminated with Heavy Metals." Hazardous Materials Control. November/December 1992.

Verscheuren, K. 1983. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Company, New York, New York.

SECTION 5.0 TABLES

TABLE 5-1

ORGANIC PHYSICAL AND CHEMICAL PROPERTIES
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

COPCs	Vapor Pressure (mm Hg)	Water Solubility (mg/L)	Log Kow	Koc	Specific Gravity (g/cm^3)	Henry's Law Constant (atm-m^3/mole)	Mobility Index	Mobility Description
Volatiles:								
Styrene	5	300	NA	NA	0.9	NA	NA	NA
Semivolatiles:								
N-Nitrosodiphenylamine	1.0E-01	40	2.57-3.13	832-1,820	1.23	6.6E-04	-2.3/-2.7	Slightly mobile
Bis(2-ethylhexyl)phthalate	6.45E-06	0.3	5.11	4-5	NA	1.1E-05	NA	NA
Di-n-butylphthalate	1E-05	13	5.6	1.7E+05	1.05	2.82E-07	-4.1/-2.9	Slightly mobile
Pesticides:								
4,4'-DDD	1.0E-06	0.09	5.99	4.47	NA	2.20E-08	-12	Very immobile
4,4'-DDE	6.5E-06	0.04	4.28	3.66	NA	6.80E-05	-10	Very immobile
4,4'-DDT	1.9E-07	0.0034	6.19	4.89	NA	1.58E-05	-14	Very immobile
Dieldrin	1.78E-07	0.195	3.5	1700	1.75	4.58E-07	-12	Very immobile
Endosulfan sulfate (1)	1E-05	0.51, 0.45	3.83	NA	NA	1.12E-05	NA	NA
alpha-Chlordane (2)	4.6E-04	1.0E-01	5.54	NA	NA	4.85E-05	NA	NA
gamma-Chlordane (2)	4.6E-04	1.0E-01	5.54	NA	NA	4.85E-05	NA	NA
PCBs:								
Aroclor-1260 (3)	7.7E-05	3.1E-02	6.04	5.3E+05	1.41	1.07E-03	-11	Very immobile

Notes:

NA = Not Available
(1) = Values substituted from endosulfan.
(2) = Values substituted from chlordane.
(3) = Values substituted from PCBs.

References:

Howard, 1989-1991
USEPA, 1986 (SPHEM)
SCDM, 1991

6.0 BASELINE HUMAN HEALTH RISK ASSESSMENT

The following subsections present the baseline human health risk assessment (BRA) conducted for Site 63, Verona Loop Dump. This assessment was performed in accordance with the USEPA document Risk Assessment Guidance for Superfund, Human Health Evaluation Manual: Part A (USEPA, 1989). The purpose of the BRA is to assess whether the contaminants of potential concern (COPCs) at the site pose a current or future risk to human health in the absence of remedial action. COPCs are site-related contaminants used to quantitatively estimate human exposures and associated potential health effects. Because the purpose of the risk assessment is to estimate the degree of risk to human health and to be protective of human health, the approach of the USEPA guidance is designed to be conservative. This protectiveness is achieved by the use of assumptions and models that result in upper bound estimates of risk; the true or actual risk is expected to fall between the estimated value and zero. As a result, the actual site risks are unlikely to exceed the estimated upper bound values and are probably lower. The following paragraphs present a brief overview of the risk assessment process and how the assessment affects further activity at the sites.

For the BRA, both current and future land use exposure scenarios were assumed for the site. The current scenario reflects potential human exposure pathways to the COPCs that presently exist at the site (i.e., exposure pathways currently available). Likewise, the future use scenario represents exposure pathways that are conceivable in the future (i.e., residential development). The future use is typically determined by zoning and the environmental setting of the site. The development of current and future use exposure scenarios is consistent with the methodology for baseline risk assessment, as specified by USEPA.

The National Contingency Plan (NCP) stipulates a range of acceptable cancer risk levels of $1x10^{-4}$ to $1x10^{-6}$ for total risk at a hazardous waste site (USEPA, 1990). These cancer risk levels represent the probability of an individual developing cancer over his or her lifetime if exposed to the COPCs at the site. For example, a risk level of 10^{-6} is the probability that one person in 1,000,000 exposed persons will develop cancer in a lifetime. The total noncarcinogenic acceptable risk level is a hazard index of less than or equal to 1.0. This noncarcinogenic risk level depicts a level at or below which adverse systemic effects are not expected in the exposed population.

A remedial action may be recommended when either the total cancer or noncancer risks are above the criteria established by the NCP. Some form of remedial action may also be necessary when either the current or future exposure point concentrations at the site are above the applicable or suitable analogous standards (e.g., maximum contaminant levels [MCLs] for drinking water) for those COPCs for which standards exist. When a remedial action is necessary, applicable or relevant and appropriate requirements (ARARs) and/or risk-based cleanup levels are used in determining acceptable concentrations in the environmental media. No remedial response is required when the carcinogenic and noncarcinogenic criteria and the ARARs are not exceeded.

6.1 Introduction

The BRA investigates the potential for COPCs to affect human health and/or the environment, both now and in the future, under a "no further remedial action scenario." The BRA process evaluates the data generated during the sampling and analytical phase of the RI, identifying areas of interest and COPCs with respect to geographical, demographic, and physical and biological characteristics of the study area. These, combined with the current understanding of physical and chemical properties of the site-associated constituents (with respect to environmental fate and transport processes), are then used to estimate the concentrations of contaminants at the end points of logical exposure pathways. Finally, contaminant intakes by potential current and future receptors are determined and combined with the toxicological properties of the contaminants to estimate (inferentially) the potential public health impacts posed by constituents detected at the site.

The BRA for the site was conducted in accordance with current USEPA Risk Assessment Guidance (USEPA, 1989 and USEPA, 1991a), and USEPA Region IV Supplemental Risk Guidance (USEPA, 1992c).

The components of the BRA include the following:

- Hazard Identification: determination as to whether a substance has the potential to elicit an adverse effect (toxicity) upon exposure to humans.

- Exposure Assessment: identification of the human population(s) likely to be exposed and the development of specific exposure pathways for the population.

- Toxicity Assessment: quantification of the relationship between the human exposure and the probability of occurrence (risk) of a toxic response.

- Risk Characterization: development of a quantitative estimation of the potential risk from a combination of information collected during the exposure and toxicity assessment.

- Uncertainty Analysis: identification and qualitative discussion of any major sources of uncertainty pertaining to the finding of the BRA.

- Conclusions: summarization and conclusion of the results of the BRA relating to the total site risk are drawn.

Each of these components of the BRA is discussed and addressed for the site. Introductory text is presented first, followed by a site-specific discussion. Referenced tables and figures are presented after the text portion of this section.

6.2 Hazard Identification

Data generated during the remedial investigation and previous studies at the site were used to draw conclusions and to identify data gaps in the BRA. The data were evaluated to assess which data were of sufficient quality to include in the risk assessment. The objective when selecting data to include in the risk assessment was to provide accurate and precise data to characterize contamination and evaluate exposure pathways.

6.2.1 Data Evaluation and Reduction

The initial hazard identification step entailed the validation and evaluation of the site data to determine its usability in the risk assessment. This process resulted in the identification of COPCs for the site. During this validation and evaluation, data that would result in inaccurate conclusions (e.g., data that were rejected or attributed to blank contamination, as qualified by the validator) were reduced within the data set. Data reduction entailed the removal of unreliable data from the original data set based on the guidelines established by USEPA. Section 6.2.3 presents the criteria that were used to review, reduce, and summarize the analytical data. A summary of the data quality was presented in Section 4.0.

6.2.2 Identification of Data Suitable for Use in a Quantitative Risk Assessment

Data collected during the November, 1995 sampling event were evaluated in this risk assessment. The previous investigations conducted at this site are detailed in Section 1.0 of this report. Five environmental media were investigated at Site 63 during this RI: surface soils, subsurface soils, shallow groundwater, surface water, and sediment. For the BRA, the surface soil and subsurface soil data were evaluated as single data sets. That is, the data were not segregated into areas of concern. Surface water and sediment samples were collected from an unnamed tributary that borders the site to the east. These media were assessed for potential risk to human receptors.

Information relating to the nature and extent of contamination at the site is provided in detail in Section 4.0 of this volume of the report. The discussion provided in Section 4.0 also was utilized in the selection of COPCs at the site. The reduced data sets for all media of concern at the site are provided in Appendices H and I of this report.

6.2.3 Criteria Used in Selection of COPCs

This section presents the criteria used in the selection of COPCs for the evaluation of potential human health risk. As exemplified by the data summary tables in Appendices H and I, the number of constituents positively detected at least once during the field investigation is large. Quantifying risk for all positively identified parameters may distract from the dominant risks presented by the site. Therefore, the data set (resulting data set after applying the criteria listed in this section) was reduced to a list of COPCs. As stated previously, COPCs are site-related contaminants used to quantitatively estimate human exposures and associated potential health effects.

The selection of the COPCs was based on a combination of historical information, comparison to background or naturally occurring levels, comparison to field and laboratory blank data, comparison to USEPA Region III Contaminants of Concern (COCs), prevalence, federal and state criteria and standards, toxicity, persistence, and mobility. USEPA guidance states that a contaminant may not be retained for quantitative evaluation in the BRA if: (1) it is detected infrequently in an environmental medium (e.g., equal to or less than 5 percent for at least 20 samples per data set), (2) it is absent or detected at low concentrations in other media, or (3) site history does not provide evidence the contaminant to be present (USEPA, 1989). A brief description of the selection criteria used in choosing final COPCs is presented below. A contaminant did not need to meet the criteria of all of these three categories in order to be retained as a COPC.

6.2.3.1 Site Setting

The Verona Loop Dump (Site 63) is comprised of approximately five acres and is located nearly two miles south of the MCAS, New River operations area. Vehicle access to the site is via Verona Loop Road, east from U.S. Route 17. The study area is located along Verona Loop Road approximately 1.25 miles from U.S. Route 17. The site is bordered to the south by Verona Loop Road, to the east by an unnamed tributary to Mill Run, and to the west by a gravel access road.

Site 63 is relatively flat. However, the eastern portion slopes toward an intermittent stream along the eastern boundary of the study area. This unnamed tributary that borders the study area to the east discharges into Mill Run approximately 2,000 feet south of Site 63. Mill Run then discharges into the Southwest Creek which eventually flows into the New River. A drainage ditch along Verona Loop Road receives surface water runoff from the extreme southern portion of the site and the asphalt road surface.

Much of the site is heavily vegetated with dense understory and trees greater than three inches in diameter. A partially improved gravel road provides access to the main portion of the study area; other unimproved paths extend outward from this road. Several personnel entrenchments, used during training exercises, have been excavated throughout the study area. Earthen berms and small to medium size trees have been felled to construct protective works around many of the entrenchments.

Site History

Very little information is known regarding the history or occurrence of waste disposal practices at Site 63. The study area reportedly received wastes generated during training exercises. The types of materials generated during these exercises are described only as bivouac wastes. Additional information suggests that no hazardous wastes were disposed at Site 63. The years during which disposal operations may have taken place are not known.

The Verona Loop portion of MCB, Camp Lejeune, which includes Site 63, is currently unrestricted to military personnel. Training exercises, maneuvers, and recreational hunting are frequently conducted in the area.

6.2.3.2 Background or Naturally Occurring Levels

Sample concentrations were compared to base-specific (i.e., twice the base-wide average concentration) background levels. Background information was available for all media of concern at the site, except groundwater. The results of these comparisons are presented in Tables 6-2 through 6-8.

6.2.3.3 Contaminant Concentrations in Blanks

Associating contaminants detected in field related QA/QC samples (i.e., trip blanks, equipment rinsates, and/or field blanks) or laboratory method blanks with the same contaminants detected in analytical samples can eliminate non-site-related contaminants from the list of COPCs. Blank data should be compared to sample results with which the blanks are associated; however, due to the comprehensive nature of data sets, it is difficult to associate specific blanks with specific environmental samples. Thus, in order to evaluate contaminant levels, maximum contaminant concentrations reported in a given set of blanks are applied to an entire data set for a given medium.

In accordance with the National Functional Guidelines for Organics, common lab contaminants (i.e., acetone, 2-butanone, methylene chloride, toluene, and phthalate esters) should be regarded as a direct result of site activities only when sample concentrations exceed 10 times the maximum blank concentration. For other contaminants not considered common in a lab, concentrations exceeding five times the maximum blank concentration indicate contamination resulting from site activities (USEPA, 1991).

When evaluating contaminant concentrations in soil, Contract Required Quantitation Limits (CRQLs) and percent moisture are employed, in order to correlate solid and aqueous detection limits. The CRQL for semivolatiles (SVOCs) and pesticide/PCBs in soil is 33 to 66 times that of aqueous samples, depending on the contaminant. In order to assess SVOC and pesticide/PCB contaminant levels in soil using aqueous blanks, blank concentrations must be multiplied by 33 or 66 to account for variance from the CRQL. The final value is divided by the sample percent moisture, in order to account for the aqueous-to-solid blank medium adjustment.

Blanks containing organic constituents that are not considered common laboratory contaminants (i.e., all other TCL compounds) are regarded as positive results only when observed concentrations exceed five times the maximum concentration detected in any blank (USEPA, 1991). All TCL compounds at concentrations less than five times the maximum level of contamination noted in any blank are considered not detected in that sample. Maximum concentrations of common laboratory contaminants and other contaminants detected in blanks are presented in Table 6-1.

6.2.3.4 USEPA Region III COC Screening Values

COC screening values are derived using conservative USEPA promulgated default values and the most recent toxicological criteria available. COC screening values for potentially carcinogenic and noncarcinogenic chemicals are individually derived based on a target incremental lifetime cancer risk (ICR) of $1x10^{-6}$ and a target hazard quotient of 0.1, respectively. For potential carcinogens, the toxicity criteria applicable to the derivation of COC screening values are oral and inhalation cancer slope factors; for noncarcinogens, they are chronic oral and inhalation reference doses. These toxicity criteria are subject to change as more updated information and results from the most recent toxicological/epidemiological studies become available. Therefore, the use of toxicity criteria in the derivation of COC screening values requires that the screening concentrations be updated periodically to reflect changes in the toxicity criteria.

Since the most recent COC screening values table was issued by USEPA in October 1995, the values from these tables can be updated by incorporating information from another set of tables containing risk-based concentrations (RBCs) that are issued by USEPA Region III on a quarterly basis. The RBCs are derived using the same equations and USEPA promulgated default exposure assumptions that were used by Region III to derive the COC screening values. In addition, the quarterly RBCs for potentially carcinogenic chemicals are based on a target ICR of $1x10^{-6}$. The only difference in the derivation methodologies for the COC screening values and the RBCs is that the RBCs for noncarcinogens are based on a target hazard quotient of 1.0 rather than 0.1. The COC screening values for noncarcinogens are to be derived based on a target hazard quotient of 0.1, to account for cumulative risk from multiple chemicals in a medium. Re-derivation of the quarterly noncarcinogenic RBCs based on a target hazard quotient of 0.1, while using the most recent toxicological criteria available, results in a set of values that can be used as COC screening values. In other words, an updated set of COC screening values can be attained each quarter by using the carcinogenic RBCs issued quarterly by USEPA Region III and dividing the accompanying noncarcinogenic RBCs by a factor of 10.

6.2.3.5 Frequency of Detection

In general, constituents that were detected infrequently (e.g., equal to or less than 5 percent, when at least 20 samples of a medium are available) may be anomalies due to sampling or analytical errors or may be present simply in the environment due to past or current site activities. It should be noted, however, that detected constituents were individually evaluated prior to exclusion from the BRA. Physiochemical properties (i.e., fate and transport) and toxicological properties for each detected constituent were evaluated (see following sections).

6.2.3.6 Federal and State Criteria and Standards

Contaminants detected at the site were compared to state and federal standards, criteria, and/or to be considered levels (TBCs). These comparisons may provide some qualitative information as to the relative potential for health impacts resulting from the site. It should be noted that COPC concentration ranges were directly compared to each standard/criteria/TBC. This comparison did not take into account the additive or synergistic effects of those constituents without standards or criteria. Consequently, conclusions regarding potential risk posed by each site cannot be inferred from this comparison. A brief explanation of the standards/criteria/TBCs used for the evaluation of COPCs is presented below.

North Carolina Water Quality Standards (NCWQSs) - Groundwater - NCWQSs are the maximum allowable concentrations resulting from any discharge of contaminants to the land or waters of the state, which may be tolerated without creating a threat to human health or which otherwise render the groundwater unsuitable for its intended purpose.

Maximum Contaminant Levels (MCLs) - Federal Groundwater Standards - 40 CFR 161 - MCLs are enforceable standards for public water supplies promulgated under the Safe Drinking Water Act and are designed for the protection of human health. MCLs are based on laboratory or epidemiological studies and apply to drinking water supplies consumed by a minimum of 25 persons. They are designed for prevention of human health effects associated with a lifetime exposure (70-year lifetime) of an average adult (70 kg) consuming 2 liters of water per day. MCLs also consider the technical feasibility of removing the contaminant from the public water supply.

Health Advisories (HAs) - HAs are guidelines developed by the USEPA Office of Drinking Water for nonregulated constituents in drinking water. These guidelines are designed to consider both acute and chronic toxic effects in children (assumed body weight 10 kg) who consume 1 liter of water per day or in adults (assumed body weight 70 kg) who consume 2 liters of water per day. HAs are generally available for acute (1 day), subchronic (10 days), and chronic (longer-term) exposure scenarios. These guidelines are designed to consider only threshold effects and, as such, are not used to set acceptable levels of potential human carcinogens.

North Carolina Water Quality Standards (Surface Water) - The NCWQSs for surface water are the standard concentrations that, either alone or in conjunction with other wastes in surface waters, will neither render waters injurious to aquatic life, wildlife, or public health, nor impair the waters for any designated use.

Ambient Water Quality Criteria - AWQCs are non-enforceable regulatory guidelines and are of primary utility in assessing acute and chronic toxic effects in aquatic systems. They may also be used for identifying the potential for human health risks. AWQCs consider acute and chronic effects in both freshwater and saltwater aquatic life, and potential carcinogenic and noncarcinogenic health effects in humans from ingestion of both water (2 liters/day) and aquatic organisms (6.5 grams/day), or from ingestion of water alone (2 liters/day). The human health AWQCs for potential carcinogenic substances are based on the USEPA's specified incremental cancer risk range of one additional case of cancer in an exposed population of 10,000,000 to 100,000 (i.e., the 10^{-7} to 10^{-5} range).

Sediment Screening Levels - Sediment Screening Levels (SSLs) have been compiled to evaluate the potential for contaminants in sediments to cause adverse health effects (Long, et.al, 1995 and USEPA, 1995b). The lower ten percentile (Effects Range-Low [ER-L]) and the median percentile (Effects Range-Median [ER-M]) of biological effects have been developed for several contaminants. The concentration below the ER-L represents a minimal-effects range (adverse effects would be rarely observed). The concentration above the ER-L but below the ER-M represents a possible-effects range (adverse effects would occasionally occur). Finally, the concentration above the ER-M represents a probable-effects range (adverse effects would probably occur).

As stated previously, COPCs in all media of concern at the site were compared with these aforementioned criteria. The results of the standards/criteria/TBC comparison for the site are presented in Tables 6-2 through 6-8.

6.2.3.7 Toxicity

The potential toxicity of a contaminant is an important consideration when selecting COPCs for further evaluation in the human health assessment. For example the weight-of-evidence (WOE) classification should be considered in conjunction with concentrations detected at the site. Some effects considered in the selection of COPCs include carcinogenicity, mutagenicity, teratogenicity, systemic effects, and reproductive toxicity. Bioaccumulation and bioconcentration properties may affect the severity of the toxic response in an organism and/or subsequent receptors and are evaluated if relevant data exist.

Despite their inherent toxicity, certain inorganic analytes are essential nutrients. These analytes are calcium, iron, magnesium, potassium, and sodium. Essential nutrients need not be considered for further consideration in the quantitative risk assessment if they are present in relatively low concentrations (i.e., below twice the average base-wide background levels or slightly elevated above naturally occurring levels) or if the contaminant is toxic at doses much higher than those which could be assimilated through exposures at the site. Due to the difficulty of determining nutrient levels that were within acceptable dietary levels, only essential nutrients present at low concentrations (i.e., only slightly elevated above background) were eliminated from the BRA. Essential nutrients, however, were included in the ecological risk evaluation.

6.2.3.8 Physiochemical Properties

Mobility

The physical and chemical properties of a contaminant are responsible for its transport in the environment. These properties, in conjunction with site conditions, determine whether a contaminant will tend to volatilize into the air from surface soils or surface waters or be transported via advection or diffusion through soils, groundwaters, and surface waters. Physical and chemical properties also describe a contaminant's tendency to adsorb onto soil/sediment particles. Environmental mobility can correspond to either an increased or decreased potential to affect human health and/or the environment.

Persistence

The persistence of a contaminant in the environment depends on factors such as the microbial content of soil and water, organic carbon content, the concentration of the contaminant, climate, and the ability of the microbes to degrade the contaminant under site conditions. In addition, chemical degradation (i.e., hydrolysis), photochemical degradation, and certain fate processes such as sorption may contribute to the elimination or retention of a particular compound in a given medium.

6.2.4 Contaminants of Potential Concern (COPCs)

The following sections present an overview of the analytical data obtained for each medium and the subsequent retention or elimination of COPCs using the aforementioned criteria for selection of COPCs. Tables 6-2 through 6-8 summarize the selection of COPCs for Site 63. Appendix N contains COPC selection summary worksheets.

6.2.4.1 Surface Soil

Forty-six surface soil samples were analyzed for volatile organic compounds (VOCs). Methylene chloride and acetone were detected at maximum concentrations less than the respective USEPA Region III residential soil COC values. For this reason, these compounds are not retained as COPCs.

Forty-six surface soil samples were analyzed for semivolatile organic compounds (SVOCs). N-nitrosodiphenylamine, di-n-butylphthalate, and bis(2-ethylhexyl)phthalate were detected at maximum concentrations less than the respective residential soil COC screening values. For this reason, these compounds are not retained as COPCs.

Forty-six surface soil samples were analyzed for pesticide/PCBs. The following compounds were detected at maximum concentrations less than respective residential soil COC values: dieldrin, 4,4'-DDE, 4,4'-DDD, endosulfan sulfate, 4,4'-DDT, alpha-chlordane, and gamma-chlordane. For this reason, these compounds are not retained as COPCs.

Aroclor-1260 was detected at a maximum concentration that exceeded its residential COC screening value. Although Aroclor-1260 was detected at a frequency less than 5 percent, it is retained as a COPC because its carcinogenicity.

Forty-six surface soil samples were analyzed for inorganic analytes. The following constituents were detected at maximum concentrations less than respective residential soil COC values: aluminum, barium, cadmium, chromium, cobalt, copper, mercury, nickel, selenium, silver, vanadium, and zinc. For this reason, these inorganics are not retained as COPCs. Lead was detected at a maximum concentration less than the action level; consequently, it is not retained as a COPC. Antimony was detected at a maximum concentration less than twice the background level; consequently, it is not retained as a COPC. Calcium, magnesium, potassium, and sodium are not retained as COPCs because these inorganics are considered essential nutrients.

Arsenic, beryllium, iron, and manganese were detected frequently in surface soil samples (i.e., greater than 5 percent). In addition, these metals were detected at maximum concentrations exceeding residential soil COC values, background levels and maximum concentrations detected in blanks. Consequently, these analytes are retained as COPCs.

6.2.4.2 Subsurface Soil

Fifty subsurface soil samples were analyzed for VOCs. Methylene chloride, acetone, and styrene were detected at maximum concentrations less than respective residential soil COC values. For this reason, these compounds are not retained as COPCs.

Fifty subsurface soil samples were analyzed for SVOCs. N-nitrosodiphenylamine and bis(2-ethylhexyl)phthalate were detected at maximum concentrations less than respective residential soil COC values. For this reason, these compounds are not retained as COPCs.

Fifty subsurface soil samples were analyzed for pesticide/PCBs. Dieldrin, 4,4'-DDE, 4,4'-DDD, and 4,4'-DDT were detected at maximum concentrations less than respective residential soil COC values. For this reason, these compounds are not retained as COPCs.

Fifty subsurface soil samples were analyzed for inorganic constituents. The following metals were detected at maximum concentrations less than respective residential soil COC values: cobalt, copper, nickel, selenium, silver, vanadium, and zinc. For this reason, these inorganics are not retained as COPCs. Thallium was detected at a maximum concentration less than the background level; consequently, it is not retained as a COPC. Calcium, magnesium, potassium, and sodium are not retained as COPCs because these inorganics are considered essential nutrients.

Aluminum, antimony, arsenic, barium, beryllium, chromium, iron, lead, and manganese were detected frequently in subsurface soil samples (i.e., frequency greater than 5 percent). In addition, these analytes were detected at maximum concentrations exceeding respective residential soil COC values, background levels, and maximum concentrations detected in blanks. Consequently, these analytes are retained as COPCs.

6.2.4.3 Groundwater

Eleven groundwater samples were analyzed for VOCs. VOCs were not detected in the groundwater. Therefore, no VOCs are retained as groundwater COPCs.

Eleven groundwater samples were analyzed for SVOCs. Bis(2-ethylhexyl)phthalate was detected at a maximum concentration less than the maximum concentration detected in blanks. For this reason, it is not retained as a COPC.

Eleven groundwater samples were analyzed for pesticide/PCBs. There were no pesticide/PCBs detected in groundwater samples. Therefore, no pesticide/PCBs are retained as groundwater COPCs.

Eleven groundwater samples were analyzed for inorganic analytes. Aluminum and cobalt were detected at maximum concentrations less than respective USEPA Region III tap water COC screening values. For this reason, these inorganics are not retained as COPCs. Calcium, magnesium, potassium, and sodium are not retained as COPCs because these inorganics are considered essential nutrients.

Arsenic, barium, iron, lead, manganese, nickel, and zinc were detected frequently in groundwater samples (i.e., frequency greater than 5 percent). In addition, these constituents were detected at maximum concentrations exceeding respective tap water COC values. Consequently, these constituents are retained as COPCs.

6.2.4.4 Surface Water

Five surface water samples were analyzed for VOCs. Acetone was detected at a maximum concentration less than the maximum concentration detected in blanks. For this reason, it is not retained as a COPC. There were no other VOCs detected in surface water.

Five surface water samples were analyzed for SVOCs. Bis(2-ethylhexyl)phthalate was detected at a maximum concentration less than ten times the maximum concentration detected in blanks. For this reason, it is not retained as a COPC. There were no other SVOCs detected in surface water.

Five surface water samples were analyzed for pesticide/PCBs. Pesticide/PCBs were not detected in surface water samples. Therefore, no pesticide/PCBs are retained as surface water COPCs.

Five surface water samples were analyzed for inorganic constituents. Calcium, magnesium, and sodium were detected at maximum concentrations less than respective background levels. In addition, these inorganics are considered essential nutrients. Consequently, these constituents are not retained as COPCs.

Aluminum, barium, iron, lead, manganese, and zinc were detected frequently in surface water samples. In addition, these inorganics were detected at maximum concentrations exceeding respective background levels. Consequently, these metals are retained as COPCs. In addition, lead is retained as a COPC even though it was detected in blanks. This is to maintain a conservative approach to the risk assessment.

6.2.4.5 Sediment

Five sediment samples were analyzed for VOCs. VOCs were not detected in sediment samples. Therefore, no VOCs are retained as sediment COPCs.

Five sediment samples were analyzed for SVOCs. SVOCs were not detected in sediment samples. Therefore, no SVOCs are retained as sediment COPCs.

Five sediment samples were analyzed for pesticide/PCBs. 4,4'-DDT was detected at a maximum concentration less than the background level. For this reason, it is not retained as a COPC.

4,4'-DDE, 4,4'-DDD, alpha-chlordane, and gamma-chlordane were detected frequently in sediment samples. In addition, these pesticides were detected at maximum concentrations exceeding respective background levels. Consequently, these compounds are retained as COPCs.

Five sediment samples were analyzed for inorganic compounds. Calcium was detected at a maximum concentration less than the background level. In addition, it is considered an essential nutrient. Magnesium, potassium, and sodium are also considered essential nutrients. Consequently, these inorganics are not retained as COPCs.

The following metals were detected frequently in sediment samples, at maximum concentrations exceeding background levels: aluminum, arsenic, barium, beryllium, chromium, copper, iron, lead, manganese, nickel, vanadium, and zinc. Consequently, these inorganics are retained as COPCs.

6.3 Exposure Assessment

The exposure assessment addresses each potential exposure pathway via soil (surface and subsurface), groundwater, surface water, sediment, and air. To determine if human exposure via these pathways may occur in the absence of remedial action, an analysis including the identification and characterization of exposure pathways was conducted. The following four elements were examined to determine if a complete exposure pathway was present:

1) a source and mechanism of chemical release
2) an environmental transport medium
3) a feasible receptor exposure route
4) a receptor exposure point

The exposure scenarios presented in the following sections are used to estimate individual risks. Unless otherwise noted, all the statistical data associated with the factors used in the dose evaluation equations for assessing exposure were obtained from the Exposure Factors Handbook (USEPA, 1989a) and the accompanying guidance manuals. A reasonable maximum exposure (RME) scenario was utilized in this assessment, which is consistent with USEPA Region IV recommendations regarding human health risk assessment. As a result, the exposure scenarios presented include RME assumptions for the input parameters in the dose evaluation equations. These values are summarized in Table 6-9.

6.3.1 Potential Human Receptors and Adjacent Populations

The following sections provide a discussion of the potential exposure pathways and receptors at Site 63.

6.3.1.1 Site Conceptual Model for Site 63

A conceptual site model of potential sources, migration pathways, and human receptors is developed to encompass all current and future routes for potential at Site 63. Figure 6-1 presents the potential exposure pathways and receptors for Site 63. Qualitative descriptions of current and future land use patterns in the vicinity of OU No. 13 were provided in the model. All available analytical data and meteorological data were considered in addition to general understanding of the demographics of surrounding communities.

From this information, the following general list of potential receptors was developed for inclusion in the quantitative health risk analysis for Site 63:

- Current military personnel
- Current trespassers (adolescent [age 7-16 years] and adult)
- Future on-site residents (child [age 1-6 years] and adult)
- Future construction worker

The following sections present a discussion of the potential exposure pathways and receptors at Site 63.

6.3.1.2 Current and Future Scenarios

At present, the site is used for military training exercises, maneuvers, and hunting. A gravel road provides access to the site and may contribute to fugitive dust generation from vehicular traffic. The majority of Site 63 is heavily wooded and vegetated. Access to the site is not restricted; consequently, trespassing onto the site is feasible.

Current receptors include military personnel who train on-site and potential off-site trespassers (i.e., adolescent [7 to 16 years old] and adult receptors). There is a residential area located approximately one mile from Site 63. For military receptors and trespassers, potential exposure pathways are surface soil incidental ingestion, dermal contact and inhalation of fugitive dust, and surface water and sediment incidental ingestion and dermal contact while wading in the surrounding surface water. During maneuvers, personnel entrenchments are often constructed to simulate battle conditions; therefore, it was assumed that military receptors could potentially be exposed to subsurface soil at Site 63. For that reason, military personnel are evaluated for exposure to subsurface soil. Potential exposure pathways include subsurface soil incidental ingestion, dermal contact, and inhalation of fugitive dust.

At present, groundwater at the site is not used for potable purposes. Potable water is supplied by the base treatment facilities via water supply wells. There are no potable wells located within a mile radius of Site 63; consequently, current exposure to groundwater was not evaluated.

In the future case, it is expected that the site will remain a restricted military area. As stated previously, groundwater is not currently used for potable purposes. It is assumed that this will continue into the future. As a result, groundwater exposure was not assessed for future military personnel. Although it is unlikely that a future residence will be built at this site, in accordance with conservative guidance, it has been assumed that a private well will be installed on-site in the future. Consequently, groundwater exposure to a future residential child and adult receptor was assessed. The potential groundwater exposure pathways are ingestion, dermal contact, and inhalation while showering. Exposure to surface soil, surface water, and sediment were also assessed for these receptors. In addition, exposure of a future construction worker to surface soil and subsurface soil during excavation activities was assessed. For future construction workers, potential exposure pathways are soil incidental ingestion, dermal contact, and inhalation of fugitive dust.

6.3.2 Migration Exposure Pathways

In general, the migration of COPCs from site soil sources could potentially occur by the following routes:

- Vertical migration of potential contaminants from surficial soils to subsurface soils.
- Leaching of potential contaminants from subsurface soils to the water-bearing zones.
- Vertical migration from shallow water-bearing zones to deeper flow systems.
- Horizontal migration in groundwater in the direction of groundwater flow.
- Groundwater discharge into local streams.

- Wind erosion and subsequent deposition of windblown dust.

The potential for a constituent to migrate spatially and persist in environmental media is important in the estimation of potential exposure. This section describes the potential exposure pathways presented on Figure 6-1 associated with each medium and each potential human receptor group, then qualitatively evaluates each pathway for further consideration in the quantitative risk analysis. Table 6-10 presents the potential human exposure scenarios for this site.

6.3.2.1 Surface Soil

The potential release source considered in the soil pathway was the chemical residuals in the surface soils. The release mechanisms considered were volatilization, fugitive dust generation/deposition, leaching, and surface runoff. The transport media were the surface soils and air. The routes for human exposure to the contaminated soils included inhalation, ingestion, and dermal contact. Potential exposure points from the site were areas of human activity on and adjacent to the site.

Soil Ingestion and Dermal Contact

Incidental ingestion and dermal contact with surface soil in the current case are complete exposure pathways at Site 63. These exposure pathways were evaluated for the current military receptor, current trespassers, future residents, and future construction workers.

Soil Inhalation Via Volatilization

Surface soil represents a potential source of exposure at the site via volatilization of organic COPCs. The potentially exposed population includes current military personnel who may inhale contaminated air. However, no VOCs were identified as COPCs in either media at the site. Air was not sampled at the site. This pathway is not considered to be significant for the site and was not evaluated for the surface soils.

Soil Inhalation Via Fugitive Dust Generation

The surface soils in the current case and the subsurface soils in the future case represent a potential source of exposure at the site via fugitive dust generation from wind erosion and vehicular traffic on surface soils. Current military personnel, trespassers, future residents, and future construction workers may inadvertently inhale the contaminated particulates as dust while engaging in outdoor activities.

6.3.2.2 Subsurface Soil

The potential release source considered in the subsurface soil pathway was the chemical residuals in the contaminated soils. The release mechanism considered was leaching to groundwater. The transport medium was the groundwater infiltrating the subsurface soil. Therefore, exposure to subsurface soils would be indirect (i.e., leaching of contaminants to groundwater). As such, subsurface soil exposure was addressed in the groundwater pathway analysis. Also, subsurface soil is available for contact during excavation activities. As a result, exposure to subsurface soil via ingestion, dermal contact, and inhalation was evaluated for the future construction worker. Currently, military receptors are evaluated for exposure to subsurface soil resulting from training activities.

6.3.2.3 Groundwater

The potential release source considered in evaluating the groundwater pathway was contaminated soils. The release mechanism considered was soil leaching. The transport medium was the groundwater. The routes considered for human exposure to the groundwater were direct ingestion of groundwater, dermal contact during showering, and inhalation of volatilized contaminants during showering. However, since there were no VOCs retained as groundwater COPCs, inhalation was not evaluated as an exposure pathway at Site 63.

Residences located on-site in the future scenario were considered to be potential exposure points. At present, on-site groundwater is not potable. As a result, groundwater from on-site sources is not significant and was not evaluated for potential risk in the current scenario. In the future scenario, it is conservatively assumed that a potable well will be installed on-site. However, as stated previously, it is not expected that this residential scenario will be implemented in the future at these military sites. As a result, future groundwater risks on-site were assessed conservatively in accordance with guidance.

6.3.2.4 Surface Water

Potential release sources considered in evaluating the surface water pathway were the contaminated soils and groundwater. The release mechanisms considered were surface runoff and groundwater seepage. The transport medium was the surface water. The potential routes considered for human exposure to the contaminated surface water were incidental ingestion and dermal contact. Potential exposure points were areas of human activity on and adjacent to the site.

At Site 63, children, adults, and military personnel were evaluated for ingestion of and dermal exposure to the surface water from the unnamed tributary while wading during outdoor activities.

6.3.2.5 Sediment

The chemical residuals in the contaminated soils and groundwater are the potential release sources to be considered in the sediment pathway. The routes for human exposure to the contaminated sediments by the sediment pathway include ingestion and dermal contact. Potential exposure points from the site are areas of human activity adjacent to the site.

The receptors previously described for the evaluation of the surface water exposure pathways were assumed to also come in contact with the underlying sediment while wading during outdoor activities. Consequently, the receptors identified for the surface water exposure pathway were also evaluated for exposure to sediment in the current and future scenarios.

6.3.2.6 Air

There are two potential release mechanisms to be considered in evaluating the atmospheric pathway: release of contaminated particulates (i.e., fugitive dust generation) and volatilization of contaminants from soil and groundwater. The transport mechanism is the air, and the potential exposure points are the areas of human activity on and adjacent to the site.

Fugitive Dust Generation

This air pathway was evaluated as a source of exposure outdoors at the site via fugitive dust generation of contaminants. Air exposure may occur when surface soils become airborne due to wind erosion or vehicular traffic. It is assumed that military personnel, child and adult receptors, and the construction worker may inhale soil particulates while engaging in outdoor activities. This is applicable for both the current and future cases. This exposure pathway was previously assessed for surface and subsurface soil, in Sections 6.3.2.1 and 6.3.2.2, respectively.

Volatilization

The air pathway, specifically, volatilization of contaminants from groundwater, is not a source of exposure at Site 63. Since there were no VOCs retained as groundwater COPCs, inhalation of volatilized contaminants was not evaluated.

6.3.3 Quantification of Exposure

The concentrations used in the estimation of chronic daily intakes (CDIs) must be representative of the type of exposure being considered. Exposure to groundwater, sediments, and surface waters can occur discretely or at a number of sampling locations. These media are transitory in that concentrations change frequently over time. Averaging transitory data obtained from multiple locations is difficult and requires many more data points at discrete locations than exist within this site. As a result, the best way to represent groundwater, sediment, and surface water contaminants from an exposure standpoint is to use a representative exposure concentration. Soils are less transitory than the aforementioned media and in most cases, exposure occurs over a wider area (i.e., residential exposure). Therefore, an upper confidence interval was used to represent a soil exposure concentration. Soil data collected from each of these areas were used separately in estimating the potential human health risks under current and future exposure scenarios. The human health assessment for future groundwater use considered groundwater data collected from all of the monitoring wells within a site and estimated risks to individuals per area of concern.

The manner in which environmental data are represented depends on the number of samples and sampling locations available for a given area and a given medium. Ninety-fifth percent (95%) upper confidence limit (UCL) values of the arithmetic mean for a lognormal distribution were used as exposure point concentrations for surface soil, subsurface soil, groundwater, surface water, and sediment. The 95 percent UCL for the lognormal distribution was used rather than the normal distribution, since the former is generally more conservative than the latter. For exposure areas with limited amounts of data or extreme variability in measured data, the 95 percent UCL can be greater than the maximum measured concentration; therefore, in cases where the 95 percent UCL for a contaminant exceeds the maximum detected value in a given data set, the maximum result was used in the estimate of exposure of the 95 percent UCL However, the true mean may still be higher than this maximum value (i.e., the 95 percent UCL indicates a higher mean is possible), especially if the most contaminated portion of the site has not been sampled.

The 95 percent UCL of the lognormal distribution was calculated using the following equation (USEPA, 1992b):

$$UCL = e^{(\bar{x} + sH/\sqrt{n-1})}$$

where:

UCL	=	upper confidence limit
e	=	constant (base of the natural log, equal to 2.718)
$\bar{x}$	=	mean of the transformed data
s	=	standard deviation of the transformed data
H	=	H-statistic (Gilbert, 1987)
n	=	number of samples

The following criteria were used to calculate media-specific average concentrations for each parameter that was detected at least once:

- For results reported as "non-detect" (i.e., ND, U, etc.), a value of one-half of the sample-specific detection limit was used to calculate the mean. The use of one-half the detection limit commonly is assigned to non-detects when averaging data for risk assessment purposes, since the actual value could be between zero and a value just below the detection limit.

- Reported concentrations that were less than the detection limit were used to calculate the mean. Typically, these values are qualified with a "J" meaning that the value was estimated.

- Reported concentrations qualified with "R" were excluded from the data set. The data flag "R" means that the QA/QC data indicated that analytical results were not usable for quantitative purposes.

The reduced data were summarized by medium and analytical parameter type (i.e., organics and inorganics) for the site. For each parameter detected during the sampling programs, the frequency of detection, maximum concentration, minimum concentration, average (arithmetic mean) concentration, and both the normal and lognormal upper 95 percent level for the arithmetic average were summarized. This information is presented in Appendix I. It should be noted that the number of times analyzed may differ per parameter per media per area of concern. This is primarily due to data rejected due to QA/QC problems and excluded from the data set. Consequently, these data are not reflected in the number of times analyzed. Data and frequency summaries and statistical summaries are presented in Appendices H and I, respectively.

6.3.4 Calculation of Chronic Daily Intakes

In order to numerically estimate the risks for current and future human receptors at Site 63, a CDI must be estimated for each COPC in every retained exposure pathway. Appendix O contains the specific CDI equations for each exposure scenario of interest. These equations were obtained from USEPA guidance (USEPA, 1989).

The following paragraphs present the general equations and input parameters used in the calculation of CDIs for each potential exposure pathway. Input parameters were taken from USEPA's default exposure factors guidelines where available and applicable. All inputs not defined by USEPA were derived from USEPA documents concerning exposure or from best professional judgment. All exposure assessments incorporate the representative contaminant concentrations in the estimation of intakes. Therefore, only one exposure scenario was developed for each exposure route/receptor combination.

CDIs calculated for carcinogenic effects incorporate terms to represent the exposure duration (years) over the course of a lifetime (70 years, or 25,550 days). CDIs for noncarcinogenic effects, on the other hand, were estimated using the concept of an average annual exposure. The intake incorporates terms describing the exposure time and/or frequency representing the number of hours per day and the number of days per year that exposure occurs. In general, noncarcinogenic risks for many exposure routes (i.e., soil ingestion) are greater for children than adults because of the differences in body weights, similar exposure frequencies, and higher ingestion rates.

Future residential and current trespasser exposure scenarios consider 1 to 6 year old children weighing 15 kg, 7 to 16 year old adolescents weighing 37 kg, and adults weighing 70 kg on average. For current military personnel, an exposure duration of 4 years was used to estimate a military tour-of-duty. A one-year duration was used for future construction worker exposure scenarios.

6.3.4.1 Incidental Ingestion of Soil

The CDI for COPCs detected in soil was estimated for all potential human receptors and was expressed as:

$$CDI = \frac{C \ x \ IR \ x \ CF \ x \ Fi \ x \ EF \ x \ ED}{BW \ x \ AT}$$

Where:

C	=	Contaminant concentration in soil (mg/kg)
IR	=	Ingestion rate (mg/day)
Fi	=	Fraction ingested from source (dimensionless)
CF	=	Conversion factor ($1x10^{-6}$ kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT	=	Averaging time (days)

The following paragraphs discuss the exposure assumptions used in the estimation of exposure to COPCs associated with the potential ingestion of soils.

Military Personnel

During the course of daily activities at Site 63, military personnel could potentially be exposed to COPCs by the incidental ingestion of surface and subsurface soils. The IR for military personnel exposed to surficial soils, as well as subsurface soils, was assumed to be 100 mg/day (USEPA, 1989) and 100 percent of the exposure was assumed to be with facility soils containing COPCs. An occupational exposure frequency (EF) of 250 days per year (USEPA, 1992c) was used in conjunction with an exposure duration of 4 years (professional judgement). An averaging time (AT) of 70 years or 25,550 days was used for exposure to potentially carcinogenic compounds while an averaging time of 1,460 (4 years x 365 days/year) days was used for noncarcinogenic exposures. An adult average body weight (BW) of 70 kg was used (USEPA, 1989).

Trespassers

Current trespassers could potentially be exposed to COPCs in the surficial soils while outdoors. Adolescents and adults could potentially be exposed to COPCs in soils by incidental ingestion via hand to mouth contact. Ingestion rate (IR) for adults and adolescents in this scenario was assumed to be 100 mg/day (USEPA, 1991). EFs for the receptor groups were assumed to be 130 days per year (adolescent) and 43 days/year (adult) (USEPA, 1992). The exposure duration (ED) was 9 years (adolescent) and 30 years (adult) (USEPA, 1991a). Averaging times of 25,550 days for potential carcinogens and 10,950 days (30 years x 365 days/year) for noncarcinogenic constituents were used for estimating potential CDIs for adults. An AT of 3,285 days (9 years x 365 days/year) was used to estimate potential CDIs for adolescents potentially exposed to noncarcinogens. An adolescent body weight of 37 kg was used (USEPA, 1989).

Future On-Site Residents

Future on-site residents could potentially be exposed to COPCs in the surficial soils during recreational or landscaping activities around their homes. Children and adults could potentially be exposed to COPCs in soils by incidental ingestion via hand to mouth contact. Ingestion rates (IR) for adults and children in this scenario were assumed to be 100 mg/day and 200 mg/day, respectively. EFs for both receptor groups were assumed to be 350 days per year. The residential exposure duration (ED) was divided into two parts. First, a six-year exposure duration was evaluated for young children which accounts for the period of highest soil ingestion (200 mg/day), and second a 30-year exposure was assessed for older children and adults by using a lower soil ingestion rate (100 mg/day) (USEPA, 1991a). The BW for a resident child was assumed to be 15 kg, representing younger individuals. The rationale was that the younger child (1 to 6 years), as a resident, will have access to affected on-site soils. The body weight for the future resident adult is assumed to be 70 kg. Averaging times of 25,550 days for potential carcinogens and 10,950 days (30 years x 365 days/year) for noncarcinogenic constituents were used for estimating potential CDIs for adults. An AT of 2,190 days (6 years x 365 days/year) was used to estimate potential CDIs for children potentially exposed to noncarcinogens.

Construction Worker

During excavation activities, construction workers may be exposed to COPCs through the incidental ingestion of surface as well as subsurface soil. The IR for future construction workers exposed to subsurface soils was assumed to be 480 mg/day (USEPA, 1991a). An exposure frequency of 90 days per year was used in conjunction with an exposure duration of one year (USEPA, 1991a). An adult BW of 70 kg was used. A summary of the exposure factors used in the estimation of soil CDIs associated with incidental ingestion is presented in Table 6-9.

6.3.4.2 Dermal Contact with Soil

Chronic daily intakes associated with potential dermal contact of soils containing COPCs were expressed using the following equation:

$$CDI = \frac{C \times CF \times SA \times AF \times ABS \times EF \times ED}{BW \times AT}$$

Where:

C	=	Contaminant concentration in soil (mg/kg)
CF	=	Conversion factor (kg/mg)
SA	=	Skin surface available for contact (cm^2)
AF	=	Soil to skin adherence factor (1.0 mg/cm^2)
ABS	=	Absorption factor (dimensionless) - 0.01 for organics, 0.001 inorganics (USEPA, Region IV, 1992a and 1992c)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT	=	Averaging time (days)

The following paragraphs discuss the exposure assumptions used in the estimation of exposure to COPCs from dermal contact with soils.

Military Personnel

There is a potential for base personnel to absorb COPCs by dermal contact. The exposed skin surface area (4,300 cm^2) was limited to the head (1,180 cm^2), arms (2,280 cm^2), and hands (840 cm^2) (USEPA, 1992). Values for exposure duration (ED), exposure frequency (EF), body weight (BW), and averaging time (AT) were the same as those used for the incidental ingestion of soil scenario. The values for AF and ABS were provided above and are in accordance with USEPA and Region IV guidance.

Trespassers

Current trespassers could also be potentially exposed to COPCs in on-site soil through dermal contact. Skin surface areas (SA) used in this exposure scenario were developed for a reasonable worse case scenario for an individual wearing a short-sleeved shirt, shorts, and shoes. The exposed skin surface area was limited to the head, hands, forearms, and lower legs. Thus, applying 25 percent of the mean total body surface area results in a default of 5,800 cm^2 for adults. The exposed skin surface for an adolescent was 3,480 cm^2 (USEPA, 1989a). Exposure duration, exposure frequencies, body weights, and averaging times were the same as those discussed for the incidental ingestion scenario presented previously. The values for AF and ABS were provided above and are in accordance with USEPA and Region IV guidance.

Future On-Site Residents

Future on-site residents could also be potentially exposed to COPCs in on-site soil through dermal contact experienced during activities near their homes. The exposed skin surface area was limited to the head, hands, forearms, and lower legs. Thus, applying 25 percent of the mean total body surface area results in a default of 5,800 cm^2 for adults. The exposed skin surface for a child (2,300 cm^2) was estimated using an average of the 50th (866 cm^2) and the 95th (1,060 cm^2) percentile body surface for a six year old child multiplied by 25 percent (USEPA, 1992). Exposure duration, exposure frequencies, body weights, and averaging times were the same as those discussed for the incidental ingestion scenario presented previously. The values for AF and ABS were provided previously and are in accordance with USEPA and Region IV guidance.

Construction Worker

Dermal contact with surface and subsurface soil COPCs could potentially occur during excavation activities. Skin surface area (SA) used for the construction worker exposure scenario was developed for an individual wearing a short-sleeved shirt, long pants, and boots. The exposed skin surface area (4,300 cm^2) was limited to the head (1,180 cm^2), arms (2,280 cm^2), and hands (840 cm^2) (USEPA, 1992). The exposure frequency and exposure duration are the same as those discussed for incidental ingestion of subsurface soil. The values for AF and ABS were provided previously and are in accordance with USEPA and Region IV guidance. A summary of the soil exposure assessment input parameters for dermal contact is presented in Table 6-9.

6.3.4.3 Inhalation of Fugitive Particulates

Exposure to fugitive particulates was estimated for most of the receptors, i.e., military personnel, trespassers, future residents, and construction workers. These populations may be exposed during daily recreational or work-related activities. The chronic daily intake of contaminants associated with the inhalation of particulates was estimated using the following equation:

$$CDI = \frac{C \ x \ IR \ x \ EF \ x \ ED \ x \ 1/PEF}{BW \ x \ AT}$$

Where:

C	=	Contaminant concentration in soil (mg/kg)
IR	=	Inhalation rate (m^3/day)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
1/PEF	=	Particulate emission factor $1/(1.32x10^9)$ (m^3/kg)
BW	=	Body weight (kg)
AT	=	Averaging time (days)

The PEF relates the concentration in soil with the concentration of respirable particles in the air from fugitive dust emission. This relationship is derived by Cowherd (1985). The particulate emissions from contaminated sites are caused by wind erosion, and, therefore, depend on erodibility of the surface material. The PEF value was obtained from a telephone conversation with Janine Dinan of USEPA (USEPA, 1995c).

The following paragraphs discuss the exposure assumptions used in the estimation of exposure to COPCs from the inhalation of particulates.

Military Personnel

During work-related activities, military personnel may inhale COPCs emitted as fugitive dust. An inhalation rate 20 m^3/day was used for military personnel (USEPA, 1991a). Values for exposure duration, exposure frequency, body weight, and averaging time were the same as those used for the incidental ingestion scenario.

Trespassers

Trespassers may also inhale particulates. The inhalation rate (IR) used in this exposure scenario was 20 m^3/day (USEPA, 1989) for adults and adolescents. Exposure frequencies, duration, body weights, and averaging time were the same as those used for the incidental ingestion scenario. Table 6-9 presents the exposure factors used to estimate CDIs associated with the particulate inhalation scenario.

Future On-Site Residents

Future on-site residents may also inhale particulates. Inhalation rates (IR) used in the on-site resident exposure scenario were 20 m^3/day (USEPA, 1989) and 15 m^3/day (USEPA, 1995d) for adults and children, respectively. Exposure frequencies, duration, body weights, and averaging time were the same as those used for the incidental ingestion scenario. Table 6-9 presents the exposure factors used to estimate CDIs associated with the particulate inhalation scenario.

Construction Worker

Construction workers could become exposed to surface and subsurface soil particulates during excavation activities. The inhalation rate (IR) used was 20 m^3/day (USEPA, 1989). Exposure frequencies, duration, body weight, and averaging time were the same as those used for the soil incidental ingestion scenario. Table 6-9 presents the exposure factors used to estimate CDIs associated with the particulate inhalation scenario.

6.3.4.4 Ingestion of Groundwater

As stated previously, shallow groundwater is not currently being used as a potable supply at Site 63. Development of the shallow aquifer for potable use is unlikely because of its general water quality and poor flow rates. However, residential housing could be constructed in the future and groundwater used for potable purposes.

The CDI of contaminants associated with the future potential consumption of groundwater was estimated using the following general equation:

$$CDI = \frac{C \times IR \times EF \times ED}{BW \times AT}$$

Where:

C	=	Contaminant concentration is groundwater (mg/L)
IR	=	Ingestion rate (L/day)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT	=	Averaging time (days)

The following paragraphs discuss the exposure assumptions used in the estimation of exposure to COPCs from the ingestion of groundwater.

Future On-Site Residents

Exposure to COPCs via ingestion of groundwater was retained as a potential future exposure pathway for both children and adults. An IR of 1 L/day was used for the amount of water consumed by a 1 to 6 year old child weighing 15 kg. The IR was 2 L/day for the adult receptor. This ingestion rate provides a conservative exposure estimate (for systemic, noncarcinogenic toxicants) designed to protect young children who may be more affected than adolescents, or adults. This value assumes that children obtain all the tap water they drink from the same source for 350 days/year (which represents the exposure frequency [EF]). An averaging time (AT) of 2,190 days (6 years x 365 days/year) is used for noncarcinogenic compound exposure. The ingestion rate (IR) for adults was 2 liters/day (USEPA, 1989a). The ED used for the estimation of adult CDIs was 30 years (USEPA, 1989), which represents the national upper-bound (90th percentile) time at one residence. The averaging time for noncarcinogens was 10,950 days. An averaging time (AT) of 25,550 days (70 years x 365 days/year) was used to evaluate exposure for both children and adults to potential carcinogenic compounds. Table 6-9 presents a summary of the input parameters for the ingestion of groundwater scenarios.

6.3.4.5 Dermal Contact with Groundwater

The CDI associated with the dermal contact with groundwater was estimated using the following general equation:

$$CDI = \frac{C \ x \ SA \ x \ PC \ x \ ET \ x \ EF \ x \ ED \ x \ CF}{BW \ x \ AT}$$

Where:

C	=	Contaminant concentration is groundwater (mg/L)
SA	=	Surface area available for contact (cm^2)
PC	=	Dermal permeability constant (cm/hr)
ET	=	Exposure time (hour/day)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
CF	=	Conversion factor (1 L/1000 cm^3)
BW	=	Body weight (kg)
AT	=	Averaging time (days)

The following paragraphs discuss the exposure assumptions used in the estimation of exposure to COPCs from dermal contact with groundwater.

Future On-Site Residents

Children and adults could contact COPCs through dermal contact with groundwater while bathing or showering. It was assumed that bathing would take place 350 days/year using site groundwater as the sole source. The whole body skin surface area (SA) available for dermal absorption was estimated to be 10,000 cm^2 for children and 23,000 cm^2 for adults (USEPA, 1992). The permeability constant (PC) reflects the movement of a chemical across the skin and into the blood stream. The permeability of a chemical is an important property in evaluating actual absorbed dose, yet many compounds do not have literature PC values. For contaminants in which a PC value has not been established, the permeability constant was calculated (see Appendix P). An exposure time (ET) of

0.25 hour/day (USEPA, 1992) was used to conservatively estimate the duration of bathing or showering. The exposure duration, body weight, and averaging time were the same as those used for the ingestion of groundwater scenario. Table 6-9 presents the exposure factors used to estimate CDIs associated with the future dermal contact with COPCs in groundwater.

6.3.4.6 Incidental Ingestion of Surface Water

The CDIs for contaminants associated with incidental ingestion of surface water were expressed using the following equation:

$$CDI = \frac{C \times IR \times ET \times EF \times ED}{BW \times AT}$$

Where:

C	=	Contaminant concentration in surface water (mg/L)
IR	=	Ingestion rate (L/day)
ET	=	Exposure time (hours/day)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT	=	Averaging time (days)

The following paragraphs discuss the exposure assumptions used in the estimation of exposure to COPCs from the incidental ingestion of surface water.

Military Personnel

The unnamed tributary that borders Site 63 is small and seasonally intermittent. Based on this information, ingestion of surface water is highly unlikely. In order to maintain a conservative approach, however, exposure of base personnel to surface water during training activities was evaluated. The IR for military personnel exposed to surface water was assumed to be 0.05 L/day (USEPA, 1989). An exposure frequency of 48 days/year (8 days/month x 6 months) and an ET of 2.6 hour/day (USEPA, 1989) were used in conjunction with an exposure duration (ED) of four years. In addition, the values for averaging time and body weight are the same as those given for ingestion of soil.

Current Trespassers and Future Residents

It is also unlikely that current trespassers or future residents will ingest surface water from the unnamed tributary. Adults, adolescents, and children who could potentially come into contact with the surface water when considering a wading scenario were assumed to conservatively ingest surface water at a rate of 0.05 L/day. In addition, an exposure frequency (EF) of 48 days/year (8 days/month x 6 months), an ET of 2.6 hour/day, and an exposure duration (ED) of 6 years for a future child resident (1-6 years), 9 years for an adolescent trespasser (7-16 years), and 30 years for an adult trespasser and future resident were used (USEPA, 1989). A summary of the surface water exposure factors associated with incidental ingestion of surface water is presented in Table 6-9.

6.3.4.7 Dermal Contact with Surface Water

The CDIs of contaminants associated with dermal contact of surface water were determined using the following general equation:

$$CDI = \frac{C\ x\ SA\ x\ PC\ x\ ET\ x\ EF\ x\ ED\ x\ CF}{BW\ x\ AT}$$

Where:

C	=	Contaminant concentration in surface water (mg/L)
CF	=	Conversion factor (0.001L/cm^3)
SA	=	Surface area available for contact (cm^2)
PC	=	Chemical-specific dermal permeability constant (cm/hr)
ET	=	Exposure time (hour/day)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT	=	Averaging time (days)

The following paragraphs discuss the exposure assumptions used in the estimation of exposure to COPCs from dermal contact with surface water.

Military Personnel

The SA value for military personnel who may potentially come into contact with the surface water during training activities was assumed to be 4,300 cm^2. In addition, an EF of 48 days/year and an ED of 4 years were used. The ET was conservatively approximated at 2.6 hours/day. The values for PC were chemical-specific. For COPCs with no PC values available, the values were calculated (see Appendix P).

Current Trespassers and Future Residents

The SA values for future adult and child residents who may potentially come into contact with the surface water during wading activities were assumed to be 5,800 cm^2 and 2,300 cm^2, respectively. The SA values for current adult and adolescent trespassers who may potentially come into contact with the surface water during wading activities were assumed to be 5,800 cm^2 and 3,480 cm^2, respectively. In addition, an exposure frequency (EF) of 48 days/year (8 days/month x 6 months) and an exposure duration (ED) of 6 years for a future child resident (1-6 years), 9 years for an adolescent trespasser (7-16 years), and 30 years for an adult trespasser and future resident were used (USEPA, 1989). It was conservatively assumed that 2.6 hours/day would be the exposure time for these receptors. The values for PC were chemical-specific. The exposure factors for this potential exposure pathway are summarized in Table 6-9.

6.3.4.8 Incidental Ingestion of Sediment

The CDI of COPCs associated with the incidental ingestion of sediment was expressed using the following general equation:

$$CDI = \frac{C \times IR \times EF \times ED \times CF}{BW \times AT}$$

Where:

C	=	Contaminant concentration in sediment (mg/kg)
CF	=	Conversion factor (kg/mg)
IR	=	Ingestion rate of sediment (mg/day)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT	=	Averaging time (days)

The following paragraphs discuss the exposure assumptions used in the estimation of exposure to COPCs from incidental ingestion of sediments.

Military Personnel

Incidental ingestion of COPCs in sediment is possible during military training exercises near the unnamed tributary bordering Site 63. An IR of 100 mg/day was used in calculating the chronic daily intake for military personnel. An EF of 48 days and ED of 4 years were used. The body weight and averaging time for military personnel are the same as the values given under soil ingestion.

Current Trespassers and Future Residents

Incidental ingestion of COPCs in sediments is also possible during activities occurring in the unnamed tributary bordering Site 63. Ingestion rates of 200 mg/day and 100 mg/day, respectively, were used in calculating the chronic daily intake for future residential children and adults. An ingestion rate of 100 mg/day was used for current adult and adolescent trespassers. The exposure frequency (EF) of 48 days/year (8 days/month x 6 months) was used as a conservative site-specific assumption. An exposure duration (ED) of 6 years and 30 years was used in the estimation of potential COPCs for a child and adult future resident, respectively. ED values of 9 years and 30 years were used for an adolescent and adult trespasser, respectively. A summary of exposure factors for this scenario is presented in Table 6-9.

6.3.4.9 Dermal Contact with Sediment

The CDI of contaminants associated with the dermal contact of affected sediments was expressed using the following general equation:

$$CDI = \frac{C \times SA \times AF \times ABS \times EF \times ED \times CF}{BW \times AT}$$

Where:

C	=	Contaminant concentration in sediment (mg/kg)
CF	=	Conversion factor (1×10^{-6} kg/mg)
SA	=	Surface area available for contact (cm^2/day)
AF	=	Adherence factor (1.0 mg/cm^2)

ABS	=	Absorption factor (dimensionless) - 0.01 organics, 0.001 inorganics (USEPA, Region IV, 1992a and 1992c)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT	=	Averaging time (days)

The following paragraphs discuss the exposure assumptions used in the estimation of exposure to COPCs from dermal contact with sediment.

Military Personnel

Military personnel could also be potentially exposed to COPCs in sediment via dermal contact. As in the surface water exposure scenario, the total body surface area was 4,300 cm^2 for military personnel. Exposure duration, exposure frequencies, body weights, and averaging times were the same as those discussed for the surface water exposure scenario presented previously. The values for AF and ABS were provided with the equation and are in accordance with USEPA and Region IV guidance.

Current Trespassers and Future Residents

Future on-site residents and current trespassers could also be potentially exposed to COPCs in sediment via dermal contact. As in the surface water exposure scenario, the total body surface area was 5,800 cm^2 for adult trespassers and future residents, 2,300 cm^2 for a future child resident, and 3,480 cm^2 for an adolescent trespasser. Exposure duration, exposure frequencies, body weights, and averaging times were the same as those discussed for the surface water exposure scenario presented previously. The values for AF and ABS were provided with the equation and are in accordance with USEPA and Region IV guidance. Table 6-9 provides a complete summary of the input parameters used in the estimation of CDIs for this scenario.

6.4 Toxicity Assessment

The purpose of this section is to define the toxicological values used to evaluate the exposure to the COPCs identified in Section 6.2.4. A toxicological evaluation characterizes the inherent toxicity of a compound. It consists of the review of scientific data to determine the nature and extent of the potential human health and environmental effects associated with exposure to various contaminants.

Human data from occupational exposures are often insufficient for determining quantitative indices of toxicity because of uncertainties in exposure estimates and inherent difficulties in determining causal relationships established by epidemiological studies. For this reason, animal bioassays are conducted under controlled conditions and their results are extrapolated to humans. There are several stages to this extrapolation. First, to account for species differences, conversion factors are used to extrapolate from test animals to humans. Second, the relatively high doses administered to test animals must be extrapolated to the lower doses more typical of human exposures. For potential noncarcinogens, safety factors and modifying factors are applied to animal results when developing acceptable human doses. For potential carcinogens, mathematical models are used to extrapolate effects at high doses to effects at lower doses. Epidemiological data can be used for inferential purposes to establish the credibility of the experimentally derived indices.

The available toxicological information indicates that many of the COPCs have both potential carcinogenic and noncarcinogenic health effects in humans and/or experimental animals. Although the COPCs may cause adverse health and environmental impacts, dose-response relationships and the potential for exposure must be evaluated before the risk to receptors can be determined. Dose-response relationships correlate the magnitude of the dose with the probability of toxic effects, as discussed in the following section.

An important component of the risk assessment is the relationship between the dose of a compound (amount to which an individual or population is potentially exposed) and the potential for adverse health effects resulting from the exposure to that dose. Dose-response relationships provide a means by which potential public health impacts may be evaluated. The published information on doses and responses is used in conjunction with information on the nature and magnitude of exposure to develop an estimate of risk.

Standard carcinogenic slope factors (CSFs) and/or reference doses (RfDs) have been developed for many of the COPCs. This section provides a brief description of these parameters.

6.4.1 Carcinogenic Slope Factor

CSFs are used to estimate an upper-bound lifetime probability of an individual developing cancer as a result of exposure to a particular level of a potential carcinogen (USEPA, 1989). This factor is generally reported in units of $(mg/kg/day)^{-1}$ and is derived through an assumed low-dosage linear multistage model and an extrapolation from high to low dose-responses determined from animal studies. The value used in reporting the slope factor is the upper 95th percent confidence limit.

These slope factors are also accompanied by USEPA weight-of-evidence (WOE) classifications, which designate the strength of the evidence that the COPC is a potential human carcinogen.

In assessing the carcinogenic potential of a chemical, the Human Health Assessment Group (HHAG) of USEPA classifies the chemical into one of the following groups, according to the weight of evidence from epidemiologic and animal studies:

- **Group A** - **Human Carcinogen** (sufficient evidence of carcinogenicity in humans)
- **Group B** - **Probable Human Carcinogen** (B1 - limited evidence of carcinogenicity in humans; B2 - sufficient evidence of carcinogenicity in animals with inadequate or lack of evidence in humans)
- **Group C** - **Possible Human Carcinogen** (limited evidence of carcinogenicity in animals and inadequate or lack of human data)
- **Group D** - **Not Classifiable as to Human Carcinogenicity** (inadequate or no evidence)
- **Group E** - **Evidence of Noncarcinogenicity for Humans** (no evidence of carcinogenicity in adequate studies)

6.4.2 Reference Dose

The RfD is developed for chronic and/or subchronic human exposure to chemicals and is based solely on the noncarcinogenic effects of chemical substances. It is defined as an estimate of a daily exposure level for the human population, including sensitive populations, that is not likely to cause an appreciable risk of adverse effects during a lifetime. The RfD is usually expressed as dose (mg) per unit body weight (kg) per unit time (day). It is generally derived by dividing a no-observed-(adverse)-effect-level (NOAEL or NOEL) or a lowest observed-adverse-effect-level (LOAEL) for the critical toxic effect by an appropriate uncertainty factor (UF). Effect levels are determined from laboratory or epidemiological studies. The UF is based on the availability of toxicity data.

UFs usually consist of multiples of 10, where each factor represents a specific area of uncertainty naturally present in the extrapolation process. These UFs are presented below and were taken from the Risk Assessment Guidance Document for Superfund, Volume I, Human Health Evaluation Manual (Part A) (USEPA, 1989):

- A UF of 10 is to account for variation in the general population and is intended to protect sensitive populations (i.e., elderly, children).

- A UF of 10 is used when extrapolating from animals to humans. This factor is intended to account for the interspecies variability between humans and other mammals.

- A UF of 10 is used when a NOAEL derived from a subchronic instead of a chronic study is used as the basis for a chronic RfD.

- A UF of 10 is used when a LOAEL is used instead of a NOAEL. This factor is intended to account for the uncertainty associated with extrapolating from LOAELs to NOAELs.

In addition to UFs, a modifying factor (MF) is applied to each reference dose and is defined as:

- A MF ranging from >0 to 10 is included to reflect a qualitative professional assessment of additional uncertainties in the critical study and in the entire data base for the chemical not explicitly addressed by the preceding uncertainty factors. The default for the MF is 1.

Thus, the RfD incorporates the uncertainty of the evidence for chronic human health effects. Even if applicable human data exist, the RfD still maintains a margin of safety so that chronic human health effects are not underestimated.

Toxicity factors and the USEPA WOE classifications are presented in Table 6-11. The hierarchy (USEPA, 1989) for choosing these values was as follows:

- Health Effects Assessment Summary Table (HEAST, USEPA, 1995)
- Integrated Risk Information System (IRIS, USEPA, 1995a)

The IRIS data base is updated monthly and contains both verified CSFs and RfDs. The USEPA has formed the Carcinogen Risk Assessment Verification Endeavor (CRAVE) Workgroup to review and validate toxicity values used in developing CSFs. Once the slope factors have been verified via extensive peer review, they appear in the IRIS data base. Like the CSF Workgroup, the USEPA has formed a RfD Workgroup to review existing data used to derive RfDs. Once the reference doses have been verified, they also appear in IRIS.

HEAST on the other hand, provides both interim (unverified) and verified CSFs and RFDs. This document is published quarterly and incorporates any applicable changes to its data base.

Toxicity values will be obtained primarily from the Region III Risk-Based Concentration Table, which is based on IRIS, HEAST, and provisional and/or recommended USEPA toxicity values, in accordance with Region IV recommendations.

For some chemicals, there are no USEPA-verified toxicity values (i.e., RfDs and CSFs) available for risk quantitation. This is the case for lead. The following section provides a discussion of how lead health effects were quantified for this assessment.

For other chemicals, the toxicity values of similarly structured compounds were substituted. For this site, the chemical substitutes were as follows: endosulfan for endosulfan sulfate, chlordane for alpha-chlordane and gamma-chlordane. In addition, there are some chemicals with different toxicity values associated with the medium in which they are detected. For example, the oral RfD for cadmium differs when found in food or water. Consequently, the oral RfDs associated with food were applied for assessing soil exposure and the oral RfDs associated with water were used accordingly.

6.4.3 Dermal Adjustment of Toxicity Factors

Because there are few toxicity reference values for dermal exposure, oral values are frequently used to assess risk from dermal exposure. Most RfDs and some slope factors are expressed as the amount of substance administered per unit time and unit body weight, while exposure estimates for the dermal route are expressed as absorbed dose. Consequently, it may be necessary to adjust an oral toxicity value from an administered dose to an absorbed dose.

Region IV provides absorption efficiency values for each class of chemicals. They are as follows:

VOCs	=	0.80
SVOCs	=	0.50
Pesticides/PCBs	=	0.50
Inorganics	=	0.20

An adjusted oral RfD is the product of the absorption efficiency and the oral toxicity reference value. The adjusted oral CSF is the ratio of the oral toxicity value and the absorption efficiency. Table 6-12 presents of summary of the dermally-adjusted toxicity values used in this BRA.

6.5 Risk Characterization

This section presents and discusses the estimated incremental lifetime cancer risks (ICR) and hazard indices (HIs) for identified potential receptor groups which could be exposed to COPCs via the exposure pathways presented in Section 6.3.2.

6.5.1 Carcinogenic Compounds

These quantitative risk calculations for potentially carcinogenic compounds estimate ICR levels for an individual in a specified population. This unit risk refers to the cancer risk that is over and above the background cancer risk in unexposed individuals. For example, an ICR of 1×10^{-6} indicates that, for a lifetime exposure, one additional case of cancer may occur per one million exposed individuals.

The ICR to individuals was estimated from the following relationship:

$$ICR = \sum_{i=1}^{n} CDI_i \; x \; CSF_i$$

where CDI_i is the chronic daily intake (mg/kg/day) for compound i and CSF_i is the cancer slope in $(mg/kg/day)^{-1}$ for contaminant i. The CSF is defined in most instances as an upper 95th percentile confidence limit of the probability of a carcinogenic response based on experimental animal data, and the CDI is defined as the exposure expressed as a mass of a substance contracted per unit body weight per unit time, averaged over a period of time (i.e., six years to a lifetime). The above equation was derived assuming that cancer is a non-threshold process and that the potential excess risk level is proportional to the cumulative intake over a lifetime.

6.5.2 Noncarcinogenic Compounds

In contrast to the above approach for potentially carcinogenic effects, quantitative risk calculations for noncarcinogenic compounds assume that a threshold toxicological effect exists. Therefore, the potential for noncarcinogenic effects is calculated by comparing CDIs with threshold levels (reference doses).

Noncarcinogenic effects were estimated by calculating the hazard index (HI) which is defined as:

$$HI = HQ_1 + HQ_2 + \ldots HQ_n \text{ or}$$

$$HI = \sum_{i=1}^{n} HQ_i$$

$$\text{where } HQ_i = CDI_i / RfD_i$$

HQ_i is the hazard quotient for contaminant i, CDI_i is the chronic daily intake (mg/kg/day) of contaminant i, and RfD_i is the reference dose (mg/kg/day) of the contaminant i over a prolonged period of exposure.

6.5.3 Human Health Risks

The following paragraphs present the quantitative results of the human health evaluation for each medium and area of concern at Site 63.

Estimated ICRs were compared to the target risk range of 1×10^{-6} to 1×10^{-4}. A value of 1.0 was used for examination of the HI. The HI was calculated by comparing estimated CDIs with threshold levels below which, noncarcinogenic health effects are not expected to occur. Any HI equal to or exceeding 1.0 suggested that noncarcinogenic health effects were possible. If the HI was less than 1.0, then systemic human health effects were considered unlikely. Tables 6-13 through 6-18 present these risk results.

6.5.3.1 Current Military Personnel

The current military receptor was evaluated for potential noncarcinogenic and carcinogenic risk from exposure to the surface soil, subsurface soil, surface water, and sediment. The potential noncarcinogenic and carcinogenic risks from exposure to the surface soil (i.e., HI=0.02 and ICR=1.3×10^{-7}), the subsurface soil (i.e., HI=0.1 and ICR=5.0×10^{-7}), the surface water (i.e., HI<0.01), and sediment (i.e., HI<0.01 and ICR=2.1×10^{-8}) were within acceptable risk levels (i.e., HI<1 and 1×10^{-6}<ICR<1×10^{-4}). These results are presented in Table 6-13.

6.5.3.2 Current Adolescent Trespasser

In the current scenario, a recreational child receptor was evaluated for potential risk from exposure to site surface soils and surface water and sediment from the unnamed tributary. The potential noncarcinogenic and carcinogenic risks from exposure to the surface soil (i.e., HI=0.02 and ICR=2.8×10^{-7}), the surface water (i.e., HI=< 0.01), and sediment (i.e., HI=0.01 and ICR=8.4×10^{-8}) were within acceptable risk levels (i.e., HI<1 and 1×10^{-6}<ICR<1×10^{-4}). The results are summarized in Table 6-14.

6.5.3.3 Future Residential Child

The child receptor was evaluated for potential risk from exposure to surface soil and groundwater in the future scenario. It was assumed that current exposure to surface water and sediment also would occur in the future case.

The potential risks from exposure to surface soil (i.e., HI=0.21 and ICR=2.2×10^{-6}), groundwater (i.e., ICR=8.6×10^{-6}), surface water (i.e., HI=0.01), and sediment (i.e., HI=0.04 and ICR=2.5×10^{-7}) were within acceptable risk levels (i.e., HI<1 and 1×10^{-6}<ICR<1×10^{-4}).

In groundwater, there is a potential noncarcinogenic risk from ingestion for the child receptor. The noncarcinogenic risk level was 10.0 from groundwater ingestion. This value exceeded the acceptable risk level of one for noncarcinogenic risks. Iron and zinc in groundwater contributed to this risk. The risk results are presented in Table 6-15.

6.5.3.4 Current Adult Trespasser

In the current scenario, an adult trespasser was evaluated for potential risk from exposure to site surface soils (i.e., HI<0.1 and ICR=1.8×10^{-7}), surface water (i.e., HI<0.01), and sediment (i.e., HI=0.01 and ICR=1.6×10^{-7}). The potential noncarcinogenic and carcinogenic risks from exposure to these media were within acceptable risk levels (i.e., HI<1 and 1×10^{-6}<ICR<1×10^{-4}). These results are provided in Table 6-16.

6.5.3.5 Future Residential Adult

The adult receptor was evaluated for potential risk from exposure to surface soil and groundwater in the future scenario. Like the child receptor, it was assumed that current exposure to the surface water and sediment also would occur in the future case.

In surface soil (i.e., HI=0.03 and ICR=$1.5x10^{-6}$), groundwater (i.e., ICR=$1.8x10^{-5}$), surface water (i.e., HI<0.01), and sediment (i.e., HI=0.01 and ICR=$1.6x10^{-7}$), the potential noncarcinogenic and carcinogenic risks from exposure to these media were within acceptable levels (i.e., HI<1 and $1x10^{-6}$<ICR<$1x10^{-4}$).

In groundwater, the potential noncarcinogenic risk from ingestion does not fall within acceptable risk levels. The potential noncarcinogenic risk from groundwater ingestion was 4.5. Iron and zinc contributed to the risk. Table 6-17 is a summary of these results.

6.5.3.6 Construction Worker

The construction worker was evaluated for potential noncarcinogenic and carcinogenic risk from exposure to the surface soil and subsurface soil in the future case. Both noncarcinogenic (i.e., HI=0.03) and carcinogenic risks (i.e., ICR=$4.7x10^{-8}$) from exposure to the surface soil for this receptor fell within the acceptable risk levels. Both noncarcinogenic (i.e., HI=0.15) and carcinogenic risks (i.e., ICR=$1.8x10^{-7}$) from exposure to the subsurface soil for this receptor fell within the acceptable risk levels. Table 6-18 presents these results.

6.6 Evaluation of Lead

Lead was identified as a COPC in the subsurface soil samples collected from Site 63. This was because the maximum detected concentration of 1,650 mg/kg obtained from sample location 63-SB23 exceeded the lead action level for residential soils. Boring 63-SB23 is located within the central portion of the suspected disposal area where surface and subsurface debris was present. With the exception of boring 63-SB23, lead concentrations were observed at concentrations well below the action level.

Although the maximum detected concentration exceeded the action level, the average lead concentration in subsurface soil (43.3 mg/kg) was well below the level of health concern. In addition, detected concentrations of lead did not exceed criteria in either surface soil or groundwater. Consequently, lead was not evaluated quantitatively.

6.7 Sources of Uncertainty

Uncertainties may be encountered throughout the BRA process. This section discusses the sources of uncertainty involved with the following:

- Analytical data
- Exposure Assessment
- Toxicity Assessment
- Compounds Not Qualitatively Evaluated

In addition, the USEPA stresses the importance of recognizing the unique characteristics and circumstances of each facility and the need to formulate site-specific responses. However, many of the assumptions presented in this document were derived from USEPA guidance, which is designed to provide a conservative approach and cover a broad variety of cases. As such, the generic application of such assumptions to a site in the RME case scenario may work against the objective of formulating a site-specific response to a constituent presence (e.g., it is possible that the site risks may be overestimated).

The following sections provide a discussion of the sources of uncertainty associated with this BRA and the effects on total site risk. Table 6-19 is a summary of these sources.

6.7.1 Analytical Data

The development of a BRA depends on the reliability of and uncertainties with the analytical data available to the risk assessor. Analytical data are limited by the precision and accuracy of the analytical method of analysis. In addition, the statistical methods used to compile and analyze the data (mean concentration, standard deviation, and detection frequencies) are subject to the uncertainty in the ability to acquire data.

Data validation serves to reduce some of the inherent uncertainty associated with the analytical data by establishing the usability of the data to the risk assessor who may or may not choose to include the data point in the estimation of risk. Data qualified as "J" (estimated) were retained for the estimation of risk at OU No. 13. Data can be qualified as estimated for many reasons including a slight exceedance of holding times, high or low surrogate recovery, or intra sample variability. Organic data qualified "B" (detected in blank) or "R" (unreliable) were not used in the estimation of risk because of the unusable nature of the data. Because of the comprehensive sampling and analytical program at OU No. 13, the loss of some data points qualified "B" or "R" did not significantly increase the uncertainty in the estimation of risk.

6.7.2 Exposure Assessment

In performing exposure assessments, uncertainties can arise from two main sources. First, the chemical concentration to which a receptor may be exposed must be estimated for every medium of interest. Second, uncertainties can arise in the estimation of contaminant intakes resulting from contact by a receptor with a particular medium.

Estimating the contaminant concentration in a given medium to which a human receptor could potentially be exposed can be as simple as deriving the 95th percent upper confidence limit of the mean for a data set. More complex methods of deriving the contaminant concentration are necessary when exposure to COPCs in a given medium occurs subsequent to release from another medium or when analytical data are not available to characterize the release. In this case, modeling is usually employed to estimate the potential human exposure.

The potential inhalation of fugitive dusts from affected soils was estimated in the BRA using USEPA's Rapid Assessment of Exposure to Particulate Emissions from Surface Contaminated Sites (Cowherd et al. 1985). The Cowherd model uses a default PEF for wind erosion based on a one-half acre source area and 50 percent vegetative cover. Modeling results for fugitive dust emission exposure suggested that the potential risk associated with this pathway was not significant.

Groundwater samples were analyzed for total (unfiltered) and dissolved (filtered) inorganic contaminants. These samples were obtained from wells that were constructed using USEPA Region IV monitoring well design specifications. Groundwater taken from monitoring wells cannot be considered representative of potable groundwater or groundwater which is obtained from a domestic well "at the tap". The use of total inorganic analytical results overestimates the potential human health risks associated with potable use scenarios. However, for the sake of conservatism, total organic results were used to estimate the potential intake associated with groundwater use. It is important to note that the shallow groundwater is not currently used for potable purposes at the site. In addition, it is highly unlikely that this groundwater will be used in the future.

To estimate an intake, certain assumptions must be made about exposure events, exposure durations, and the corresponding assimilation of contaminants by the receptor. Exposure factors, have been generated by the scientific community and have undergone review by the USEPA. Regardless of the validity of these exposure factors, they have been derived from a range of values generated by studies of limited number of individuals. In all instances, values used in the risk assessment, scientific judgments, and conservative assumptions agree with those of the USEPA. Conservative assumptions designed not to underestimate daily intakes were employed throughout the BRA and should err conservatively, thus adequately protecting human health and allowing the establishment of reasonable clean-up goals.

6.7.3 Sampling Strategy

Soil represents a medium of direct contact exposure and often is the main source of contaminants released into other media. The soil sampling depth should be applicable to the exposure pathways and contaminant transport routes of concern and should be chosen purposely within that depth interval. If a depth interval is chosen purposely, a random sample procedure to select a sampling point may be established. The assessment of surface exposure at the site is based on collection of samples from the shallowest depth, zero to one foot. Subsurface soil samples are important, however, if soil disturbance is likely or leaching of chemicals to groundwater is of concern.

The surface soil samples at all sites were obtained at or very near the suspected disposal areas. Therefore, these areas would be considered areas of very high concentration which would have a significant impact on exposures.

In the future exposure scenarios, subsurface soil exposure was evaluated. It was assumed that the subsurface soil would be excavated and used as surface grading or landscaping, in the foreseeable future. It is important to note that many of these subsurface soil samples were collected at depths ranging from 1 foot to possibly up to 20 feet, depending on the depth of the well from which the soil boring was collected. It may be unrealistic to assume that excavation could occur at such depths. It follows that exposure to contaminants in soil at these depths would be unlikely for future receptors. However, for the BRA, the subsurface soil analytical results were not segregated by depth, but were evaluated as a single data set. Consequently, levels found at all depths were evaluated for potential risk to human health. The use of the entire subsurface soil data set may add to the conservative nature of the approach used to assess risk for this site.

6.7.4 Toxicity Assessment

In making quantitative estimates of the toxicity of varying doses of a compound to human receptors, uncertainties arise from two sources. First, data on human exposure and subsequent effects are usually insufficient, if they are available at all. Human exposure data usually lack adequate concentration estimations and suffer from inherent temporal variability. Therefore, animal studies are often used; new uncertainties arise from the process of extrapolating animal results to humans. Second, to obtain observable effects with a manageable number of experimental animals, high doses of a compound are used over a relatively short time period. In this situation, a high dose means that experimental animal exposures are much greater than human environmental exposures. Therefore, when applying the results of the animal experiment to humans, the effects at the high doses must be extrapolated to approximate effects at lower doses.

In extrapolating effects from animals to humans and high doses to low doses, scientific judgment and conservative assumptions are employed. In selecting animal studies for use in dose-response calculations, the following factors are considered:

- Studies are preferred where the animal closely mimics human pharmacokinetics.
- Studies are preferred where dose intake most closely mimics the intake route and duration for humans.
- Studies are preferred which demonstrate the most sensitive response to the compound in question.

For compounds believed to cause threshold effects (i.e., noncarcinogens), safety factors are employed in the extrapolation of effects from animals to humans and from high to low doses.

Conservatism is also introduced through the use of experimentally-derived oral absorption efficiencies to adjust oral toxicity criteria (i.e., CSFs and RfDs), derived during studies based on administered dosages for the estimation of dermal absorption. Equating the absorption efficiency of the bi-phasic dermal barrier to that of the mono-phasic gastrointestinal lining and then applying it to oral toxicity criteria in a dermal risk assessment scenario tends to generally overestimate the potential risk to human health by no more than an order of magnitude.

The use of conservative assumptions results in quantitative indices of toxicity that are not expected to underestimate potential toxic effects, but may overestimate these effects by an order of magnitude or more.

6.8 Conclusions of the BRA for Site 63

The BRA highlights the media of interest from the human health standpoint at Site 63 by identifying areas with risk values greater than acceptable levels. Current and future potential receptors at the site included current military personnel, current trespassers (i.e., adolescents and adults), future residents (i.e., children and adults), and future construction workers. The total risk from the site for these receptors was estimated by logically summing the multiple pathways likely to affect the receptor during a given activity. Exposure to surface soil, surface water, and sediment was assessed for the current trespassers and military receptors. Surface soil, groundwater, surface water, and sediment exposure were evaluated for the future residents. Surface soil and subsurface soil exposure were evaluated for the future construction worker.

6.8.1 Current Scenario

In the current case, the following receptors were assessed: military personnel and trespassers. Receptor exposure to surface soil, surface water, and sediment was assessed for the current trespasser. Surface soil, subsurface soil, surface water, and sediment exposure was assessed for military personnel. The potential risks associated with the current receptors were within acceptable risk levels.

6.8.2 Future Scenario

In the future case, child and adult residents were assessed for potential exposure to groundwater, surface soil, surface water, and sediment. A construction worker was evaluated for surface soil and subsurface soil exposure via ingestion, dermal contact, and inhalation of fugitive dusts. There were no unacceptable risks associated with the construction worker. However, there were potential noncarcinogenic risks calculated for the child resident from groundwater (10.0) exposure. Similarly, there was a noncarcinogenic risk (4.5) calculated for the adult resident from groundwater exposure. These risk values exceeded the hazard index of 1 for noncarcinogenic effects. The maximum level of iron and zinc in groundwater were the primary contributors to these noncarcinogenic risks.

As stated previously, groundwater is not currently used potably at the site, and future residential development of the site is unlikely. Based on this information, the future groundwater exposure scenario evaluated in this BRA, although highly protective of human health, is unlikely to occur.

It should be noted that iron is an essential nutrient. The toxicity values associated with exposure to this metal are based on provisional studies, which have not been verified by USEPA. In fact, if iron were removed from the evaluation of risk from groundwater ingestion, the noncarcinogenic risk for the child would decrease from 10.0 to 4.8 and, for the adult, from 4.5 to 2.3. As a result, the potential human health risk from exposure to iron in groundwater is a conservative and unrealistic estimate.

The other analyte contributing to the elevated HI values in groundwater for the future residential child and adult was zinc. Zinc had a HQ of 3.6 for the future child resident and 1.6 for the future adult resident. While zinc was detected at a frequency of six out of eleven samples, only one detection exceeded the comparison criteria. This exceedence of 17,100 μg/L was detected at sample location 63-TW07. This concentration of zinc is one order of magnitude greater than those detected in Site 63 soils. In addition, zinc was not detected in surface water. Consequently, the potential human health risk from exposure to zinc in groundwater is a conservative and possibly unrealistic estimate. Table 6-20 presents a summary of the total site risks.

6.9 <u>References</u>

Cowherd et al., 1985. Cowherd, C. et al. <u>Rapid Assessment of Exposure to Particulate Emissions from Surface Contamination</u>. Prepared for EPA Office of Health and Environmental Assessment. EPA/600/8-85/002.

Gilbert, R. O., 1987. <u>Statistical Methods for Environmental Pollution Monitoring</u>. Van Nostrand Reinhold, New York.

Long, E. R., et. al., 1995. "Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediment," Environmental Management, Vol. 19, No. 1, pp. 81-97. Springer-Verland, Inc., New York.

USEPA, 1989. U.S. Environmental Protection Agency. Risk Assessment Guidance for Superfund Volume I. Human Health Evaluation Manual (Part A) Interim Final. Office of Solid Waste and Emergency Response. Washington, D.C. EPA/540/1-89-002. December 1989.

USEPA, 1989a. U.S. Environmental Protection Agency. Exposure Factors Handbook. July 1989.

USEPA, 1990. U.S. Protection Agency. National Oil and Hazardous Substances Pollution Contingency Plan. 55FR8665. Office of Emergency and Remedial Response. Washington, D.C. March 1990.

USEPA, 1991. U.S. Environmental Protection Agency. National Functional Guidelines for Organic Data Review. Draft. USEPA Hazardous Site Evaluation Division. June, 1991.

USEPA, 1991a. U.S. Environmental Protection Agency. Risk Assessment Guidance for Superfund Volume I. Human Health Evaluation Manual Supplemental Guidance. "Standard Default Exposure Factors" Interim Final. Office of Solid Waste and Emergency Response. Washington, D.C. OSWER Directive 9285.6-03. March 25, 1991.

USEPA, 1992. U.S. Environmental Protection Agency. Dermal Exposure Assessment: Principles and Applications. Interim Report. Office of Health and Environmental Assessment. Washington, D.C. EPA/600/8-91/011B. January 1992.

USEPA, 1992a. U.S. Environmental Protection Agency. New Interim Region IV Guidance for Toxicity Equivalency Factor (TEF) Methodology. Region IV Water Management Division.

USEPA, 1992b. U.S. Environmental Protection Agency. Supplemental Guidance to RAGS: Calculating the Concentration Term. Office of Solid Waste and Emergency Response. Washington, D.C., Publication 9285.7-081. May 1992.

USEPA, 1992c. USEPA Region IV Supplemental Risk Guidance. February 11, 1992.

USEPA, 1994. Revised Soil Lead Guidance for CERCLA Sites and Corrective Action Facilities. OSWER Directive 9355.4-12, July 14, 1994.

USEPA, 1995. U.S. Environmental Protection Agency. Health Effects Assessment Summary Tables Annual FY-1995. Office of Solid Waste and Emergency Response. Washington, D.C. EPA/540/R-95/036 PB95-921199. May 1995.

USEPA, 1995a. U.S. Environmental Protection Agency. Integrated Risk Information System (IRIS). Environmental Criteria and Assessment Office, Cincinnati, Ohio.

USEPA, 1995b. U.S. Environmental Protection Agency. Region III Risk-Based Concentration Table. Philadelphia, Pennsylvania. October, 1995.

USEPA, 1995c. U. S. Environmental Protection Agency. Phone conversation with Janine Dinan. Washington, D.C. November 17, 1995.

USEPA, 1995d. U. S. Environmental Protection Agency. Supplemental Guidance to RAGS: Region IV Bulletins. Office of Health Assessment. Atlanta, Georgia. November, 1995.

SECTION 6.0 TABLES

TABLE 6-1

SUMMARY OF BLANK CONTAMINANT RESULTS
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB CAMP LEJEUNE, NORTH CAROLINA

Constituent	Maximum Concentration Detected in Blank (μg/L)	Medium Associated with Maximum Concentration Detected in Blank	Type of Blank with Maximum Detected Value	Concentration for Comparison[1] (Aqueous -μg/L)	Concentration for Comparison[2] (Solid - μg/kg)
Volatiles					
Methylene Chloride	13J	Soil	Rinsate	130	130
Acetone	36J	Soil	Field	360	360
Semivolatiles					
Bis(2-ethylhexyl)phthalate	56J	Soil	Field	560	18,480[3]
Inorganics					
Aluminum	28.2	Soil	Rinsate	141	141
Barium	2.6	Soil	Rinsate	13	13
Copper	15.4	Soil	Rinsate	77	77
Lead	3.4J	Soil	Rinsate	17	17
Silver	4.1	Soil	Rinsate	20.5	20.5
Zinc	6.7	Soil	Rinsate	33.5	33.5
Volatiles					
Methylene Chloride	36J	Groundwater	Field	360	NA
2-Butanone	84J	Groundwater	Rinsate	840	NA
Semivolatiles					
Bis(2-ethylhexyl)phthalate	56J	Groundwater	Field	560	NA
Inorganics					
Barium	9.2	Groundwater	Rinsate	46	NA
Lead	1.7	Groundwater	Field	8.5	NA
Volatiles					
Acetone	36J	Surface Water/ Sediment	Field	360	360
2-Butanone	49J	Surface Water/ Sediment	Rinsate	490	490
Semivolatiles					
Bis(2-ethylhexyl)phthalate	56J	Surface Water/ Sediment	Field	560	18,480[3]
Inorganics					
Lead	1.7	Surface Water/ Sediment	Field	8.5	8.5

Notes:

(1) Concentration is five or ten times (for common laboratory blank contaminants) the maximum detected concentration in a blank.
(2) Concentration is five or ten times the maximum detected concentration in a blank; converted to μg/kg.
(3) Semivolatile blank concentrations are multiplied by 33 or 66 to account for matrix difference.

NA = Not applicable

TABLE 6-2

SUMMARY OF DATA AND COPC SELECTION
ORGANICS IN SURFACE SOIL
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Parameter	Contaminant Range/Frequency		Region III Criteria	Comparison to Criteria
	Range of Positive Detections (µg/kg)	No. of Positive Detects/ No. of Samples	Residential COC Value (µg/kg)	Positive Detects Above Residential COC Value
Volatiles				
Methylene Chloride	14 - 34J	3/46	85,000	0
Acetone	11J	1/46	780,000	0
Semivolatiles				
n-Nitrosodiphenylamine	51J	1/45	130,000	0
Di-n-butylphthalate	78J	1/45	780,000	0
bis(2-Ethylhexyl)phthalate	41J - 4,400	7/45	46,000	0
Pesticide/PCBs				
Dieldrin	3J - 4.1J	3/46	40	0
4,4'-DDE	2.7J - 55J	7/45	1,900	0
4,4'-DDD	12 - 26J	2/45	2,700	0
Endosulfan Sulfate	1.9J - 2.8J	4/45	47,000(1)	0
4,4'-DDT	2J - 50J	11/45	1,900	0
Alpha-chlordane	3.5 - 16	2/45	490(2)	0
Gamma-chlordane	2.7J - 9	2/45	490(2)	0
Aroclor-1260	28J - 97	2/45	83	1

Notes:

(1) USEPA Region III COC Screening Level for endosulfan used as a surrogate.
(2) USEPA Region III COC Screening Level for chlordane used as a surrogate.

Shading indicates contaminant selected as COPC for human health risk evaluation.
J - Estimated value

TABLE 6-3

SUMMARY OF DATA AND COPC SELECTION
METALS IN SURFACE SOIL
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Analyte	Range/Frequency		Comparison to Criteria			
	Range of Positive Detections (mg/kg)	No. of Positive Detects/ No. of Samples	Twice the Average Base Specific Background[1] Concentration (mg/kg)	No. of Times Exceeded Twice the Average Background Concentration	Residential COC Value (mg/kg)	Positive Detects Above Residential COC Value
Aluminum	268J - 7,050J	46/46	5,856.083	4	7,800	0
Antimony	2.1J - 4.3J	8/40	5.455	0	3.1	3
Arsenic	0.32 - 3.7	36/46	1.322	5	0.43	30
Barium	3 - 53.1	46/46	17.292	8	550	0
Beryllium	0.1J - 0.27	5/46	0.205	1	0.15	2
Cadmium	1 - 3.1	2/46	0.696	2	3.9	0
Calcium+	10.4 - 2,780J	36/46	1,372.977	2	--	--
Chromium	1.1 - 11.1	44/46	6.607	6	39	0
Cobalt	0.49 - 4.3	7/46	2.046	2	470	0
Copper	0.47 - 74.8	29/46	7.104	10	310	0
Iron+	590 - 22,400J	46/46	3,702.427	9	2,300	19
Lead	2.6 - 107	46/46	23.37	5	400[2]	0
Magnesium+	28.4 - 223	46/46	202.96	3	--	--
Manganese	3.4J - 348J	46/46	18.51	13	190	1
Mercury	0.06 - 0.21J	4/46	0.094	1	2.3	0
Nickel	0.62J - 9.8	33/46	3.455	2	160	0
Potassium+	18.9J - 349	36/46	200.06	7	--	--
Selenium	0.27 - 0.33	2/46	0.753	0	39	0
Silver	0.72 - 0.97	2/46	0.88	1	39	0
Sodium+	5.3 - 100	7/46	59.013	1	--	--
Vanadium	2 - 11	44/46	11.447	0	55	0
Zinc	0.98 - 1,860	36/46	13.763	7	2,300	0

Notes:

(1) Soil background concentrations are based on reference background soil samples collected from MCB Camp Lejeune investigations.
(2) Action Level for residential soils (USEPA, 1994)

Shaded areas indicate analyte selected as COPC for human health risk evaluation.
+ = Essential Nutrient
-- = No criteria published
J - Estimated Value

TABLE 6-4

SUMMARY OF DATA AND COPC SELECTION
ORGANICS IN SUBSURFACE SOIL
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Parameter	Contaminant Range/Frequency: Range of Positive Detections (μg/kg)	Contaminant Range/Frequency: No. of Positive Detects/ No. of Samples	Region III Criteria: Residential COC Value (μg/kg)	Comparison to Criteria: Positive Detects Above Residential COC Value
Volatiles				
Methylene Chloride	20 - 100	5/50	85,000	0
Acetone	23J - 150J	7/50	780,000	0
Styrene	41	1/50	1,600,000	0
Semivolatiles				
N-nitrosodiphenylamine	94J - 350J	2/49	130,000	0
bis(2-Ethylhexyl)phthalate	41J - 4,700	12/49	46,000	0
Pesticide/PCBs				
Dieldrin	2.1J - 5J	2/50	40	0
4,4'-DDE	2.6J - 2.8J	2/50	1,900	0
4,4'-DDD	5.6	1/50	2,700	0
4,4'-DDT	7.8	1/50	1,900	0

Notes:

J - Estimated value

TABLE 6-5

SUMMARY OF DATA AND COPC SELECTION
METALS IN SUBSURFACE SOIL
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Analyte	Range/Frequency		Comparison to Criteria			
	Range of Positive Detections (mg/kg)	No. of Positive Detects/ No. of Samples	Twice the Average Base Specific Background[1] Concentration (mg/kg)	No. of Times Exceeded Twice the Average Background Concentration	Region III Residential COC Value (mg/kg)	Positive Detects Above Residential COC Value
Aluminum	312 - 16,000	50/50	7,413.23	32	7,800	31
Antimony	2.5J - 16.2J	7/42	6.498	1	3.1	5
Arsenic	0.4 - 16	47/50	1.971	28	0.43	46
Barium	2.5 - 1120	50/50	14.37	8	550	1
Beryllium	0.08 - 0.29	18/50	0.191	6	0.15	9
Calcium+	4 - 865J	38/50	387.824	3	--	--
Chromium	1.2 - 84.4	50/50	12.537	27	39	1
Cobalt	0.34 - 14.9	19/50	1.611	3	470	0
Copper	0.55 - 160	38/50	2.41	27	310	0
Iron+	425J - 149,000J	50/50	7,134.639	20	2,300	41
Lead	2J - 1,650	50/50	8.264	11	400[2]	1
Magnesium+	18.1 - 552	50/50	263.398	22	--	--
Manganese	1.5 - 586	50/50	7.99	18	190	2
Nickel	0.98 - 76.1	44/50	3.725	19	160	0
Potassium+	30.8 - 1,050	45/50	344.252	31	--	--
Selenium	0.31J - 0.72	10/50	0.806	0	39	0
Silver	1.8 - 5.3	2/50	0.869	2	39	0
Sodium+	7.6 - 84.6	19/50	54.57	2	--	--
Thallium	0.14 - 0.18	3/50	0.98	0	--	--
Vanadium	0.54 - 48.2	50/50	13.34	34	55	0
Zinc	1.3 - 1,130	38/50	6.668	16	2,300	0

Notes:

(1) Soil background concentrations are based on reference background soil samples collected from MCB Camp Lejeune investigations.

(2) Action Level for residential soils (USEPA, 1994).

Shaded areas indicate analyte selected as COPC for human health risk evaluation.

+ = Essential Nutrient		NA = Not Applicable	
-- = No criteria published		J = Estimated Value	

TABLE 6-6

SUMMARY OF DATA AND COPC SELECTION
ORGANICS AND METALS IN GROUNDWATER
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Parameter	Groundwater Criteria					Frequency/Range		Comparison to Criteria				
	NCWQS(1) (µg/L)	MCL(2) (µg/L)	Region III Tapwater COC Value (µg/L)	Federal Health Advisories(3) (µg/L) 10 kg Child	Federal Health Advisories(3) (µg/L) 70 kg Adult	No. of Positive Detects/ No. of Samples	Concentration Range (µg/L)	No. of Detects Above NCWQS	No. of Detects Above MCL	No. of Detects Above COC	No. of Detects Above Health Advisories 10 kg Child	No. of Detects Above Health Advisories 70 kg Adult
Semivolatiles												
bis(2-Ethylhexyl)phthalate(4)	3	6	4.8	NE	NE	2/11	1J - 11	1	1	1	NA	NA
Metals												
Aluminum	NE	50/200(5)	3,700	NE	NE	9/11	175 - 2,420	NA	9/8	0	NA	NA
Arsenic	50	50	0.045	NE	NE	1/11	1.8	0	0	1	NA	NA
Barium	2,000	2,000	260	NE	NE	11/11	16.6 - 461	0	0	1	NA	NA
Calcium+	NE	NE	NE	NE	NE	11/11	352 - 24,900	NA	NA	NA	NA	NA
Cobalt	NE	NE	220	NE	NE	5/11	4.8 - 11.9	NA	NA	0	NA	NA
Iron	300	300(5)	1,100	NE	NE	8/11	73.5 - 24,300	4	4	3	NA	NA
Lead	15	15(6)	NE	NE	NE	5/11	1.2 - 9.4	0	0	NA	NA	NA
Magnesium+	NE	NE	NE	NE	NE	11/11	529 - 5,800	NA	NA	NA	NA	NA
Manganese	50	50(5)	88	NE	NE	11/11	1.8 - 311	4	4	3	NA	NA
Nickel	100	100	73	500	1,700	9/11	12.5 - 89.4	0	0	3	0	0
Potassium+	NE	NE	NE	NE	NE	7/11	947 - 8,290	NA	NA	NA	NA	NA
Sodium+	NE	NE	NE	NE	NE	11/11	2,300 - 11,800	NA	NA	NA	NA	NA
Zinc	2,100	5,000(5)	1,100	3,000	10,000	6/11	4.9 - 17,100	1	1	1	1	1

Notes:

(1) NCWQS = North Carolina Water Quality Standards for Groundwater
(2) MCL = Safe Drinking Water Act Maximum Contaminant Level
(3) Longer Term Health Advisories for a 10 kg Child and 70 kg Adult
(4) Bis(2-ethylhexyl)phthalate was not selected as a COPC due to blank contamination.
(5) SMCL = Secondary Maximum Contaminant Level
(6) Action Level for drinking water.

\+ = Essential Nutrient
NE = No Criteria Established
NA = Not Applicable
J = Estimated Value

Shaded areas indicate parameter selected as COPC for human health risk evaluation.

TABLE 6-7

SUMMARY OF DATA AND COPC SELECTION
ORGANICS AND METALS IN SURFACE WATER
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Parameter	Surface Water Criteria			Average Background	Contaminant Frequency/Range		Comparison to Criteria		
	NCWQS[1] (µg/L)	Federal Health AWQCs[2]					Positive Detects Above NCWQS	Positive Detects Above AWQC	
		Water & Organisms (µg/L)	Organisms Only (µg/L)		No. of Positive Detects/ No. of Samples	Contaminant Range (µg/L)		Water & Organisms	Organisms Only
Volatiles									
Acetone	NE	NE	NE	ND	1/5	11J	NA	NA	NA
Semivolatiles									
Bis(2-ethylhexyl)phthalate[3]	NE	1.8	5.9	ND	1/5	100	NA	1	1
Inorganics									
Aluminum	NE	NE	NE	333.17	5/5	602 - 688	NA	NA	NA
Barium	1,000	1,000	NE	25.67	5/5	22.1 - 26.4	0	0	NA
Calcium+	NE	NE	NE	17,566.67	5/5	1,740 - 1,960	NA	NA	NA
Iron	NE	300	NE	575.67	5/5	292 - 834	NA	4	NA
Lead	NE	50	NE	ND	4/5	1 - 2.2	NA	0	NA
Magnesium	NE	NE	NE	1,744.67	5/5	678 - 809	NA	NA	NA
Manganese	200	50	100	ND	5/5	4.7 - 10	0	0	0
Sodium+	NE	NE	NE	9,830.00	5/5	4,250 - 4,480	NA	NA	NA
Zinc	NE	NE	NE	ND	5/5	5.5 - 22.6	NA	NA	NA

Notes:

(1) NCWQS = North Carolina Water Quality Standards for Surface Water
(2) AWQC = Ambient Water Quality Standard
(3) Bis(2-ethylhexyl)phthalate was not selected as a COPC due to blank contamination.

Shaded areas indicate parameter selected as COPC for human health risk evaluation.

\+ = Essential Nutrients
NE = Not Established
ND = Not Detected
NA = Not Applicable
J = Estimated value

TABLE 6-8

SUMMARY OF DATA AND COPC SELECTION
ORGANICS AND METALS IN SEDIMENT
SITE 63-VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Parameter	Sediment Screening Values(1)		Average Background	Range/Frequency		Comparison to Criteria Positive Detects Above	
	ER-L Concentration	ER-M Concentration		Range of Positive Detections	No. of Positive Detects/ No. of Samples	ER-L	ER-M
Pesticides/PCBs (µg/kg)							
4,4'-DDE	2.2	27	2.42	4.2J	1/5	1	0
4,4'-DDD	1.58(2)	46.1(2)	1.57	2.6J - 11J	2/5	2	0
4,4'-DDT	1.58(2)	46.1(2)	2.20	1.6J	1/5	1	0
Alpha-chlordane	0.5(3,4)	6(3,4)	1.20	4.7J	1/5	1	0
Gamma-chlordane	0.5(3,4)	6(3,4)	1.44	6.2J	1/5	1	1
Inorganics (mg/kg)							
Aluminum	NE	NE	1,165.57	890 - 7,050	5/5	NA	NA
Arsenic	8.2	70	0.37	0.29J - 0.63J	2/5	0	0
Barium	NE	NE	6.46	3.8 - 19.6	5/5	NA	NA
Beryllium	NE	NE	0.09	0.14J	1/5	NA	NA
Calcium+	NE	NE	1,967.14	49.9 - 178	5/5	NA	NA
Chromium	81	370	1.86	1.4J - 8.1J	4/5	0	0
Copper	34	270	0.75	2.8 - 6.9	4/5	0	0
Iron	NE	NE	433.71	84.9J - 2,050J	5/5	NA	NA
Lead	46.7	218	0.79	3.2J - 13.7J	5/5	0	0
Magnesium+	NE	NE	45.25	11.3J - 259	5/5	NA	NA
Manganese	NE	NE	3.63	1.6J - 7.5J	5/5	NA	NA
Nickel	20.9	51.6	ND	1.9	1/5	0	0
Potassium+	NE	NE	ND	27.4 - 367	4/5	NA	NA

TABLE 6-8 (Continued)

SUMMARY OF DATA AND COPC SELECTION
ORGANICS AND METALS IN SEDIMENT
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Parameter	Sediment Screening Values[1]		Average Background	Range/Frequency		Comparison to Criteria Positive Detects Above	
	ER-L Concentration	ER-M Concentration		Range of Positive Detections	No. of Positive Detects/ No. of Samples	ER-L	ER-M
Sodium+	NE	NE	ND	7.6 - 12.9	5/5	NA	NA
Vanadium	NE	NE	1.52	1.2J - 12.4J	5/5	NA	NA
Zinc	150	410	5.11	0.92 - 6.7	5/5	0	0

Notes:

(1) Long et al., 1995.
(2) Value for total DDT
(3) Region IV NOAA sediment screening value
(4) Value for total chlordane

Shaded areas indicate parameter selected as COPC for human health risk evaluation.
ER-L =Effects Range-Low
ER-M =Effects Range-Medium
\+ = Essential Nutrients
NA = Not Applicable
ND = Not Detected
NE = Not Established
J = Estimated value

TABLE 6-9

SUMMARY OF EXPOSURE DOSE INPUT PARAMETERS
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Input Parameter	Units	Receptor					
		Current Trespasser Adolescent	Current Trespasser Adult	Current Adult Military Personnel	Future Construction Worker	Future Residential Child	Future Residential Adult
Surface Soil							
Ingestion Rate, IR	mg/d	100	100	100	480	200	100
Fraction Ingested, FI	unitless	1	1	1	1	1	1
Exposure Frequency, EF	d/y	130	43	250	90	350	350
Exposure Duration, ED	y	9	30	4	1	6	30
Surface Area, SA	cm^2	3,480	5,800	4,300	4,300	2,300	5,800
Absorption Factor, AF	mg/cm^3	1	1	1	1	1	1
Averaging Time, Noncarc., ATnc	d	3,285	10,950	1,460	365	2,190	10,950
Averaging Time, Carc., ATcarc	d	25,550	25,550	25,550	25,550	25,550	25,550
Body Weight, BW	kg	37	70	70	70	15	70
Conversion Factor, CF	kg/mg	$1x10^{-6}$	$1x10^{-6}$	$1x10^{-6}$	$1x10^{-6}$	$1x10^{-6}$	$1x10^{-6}$
Absorbance Factor, ABS	unitless	Organics = 0.01; Inorganics = 0.001					
Subsurface Soil							
Ingestion Rate, IR	mg/d	NA	NA	100	480	NA	NA
Fraction Ingested, FI	unitless	NA	NA	1	1	NA	NA
Exposure Frequency, EF	d/y	NA	NA	250	90	NA	NA
Exposure Duration, ED	y	NA	NA	4	1	NA	NA
Surface Area, SA	cm^2	NA	NA	4,300	4,300	NA	NA
Absorption Factor, AF	mg/cm^3	NA	NA	1	1	NA	NA
Averaging Time, Noncarc., ATnc	d	NA	NA	1,460	365	NA	NA
Averaging Time, Carc., ATcarc	d	NA	NA	25,550	25,550	NA	NA
Body Weight, BW	kg	NA	NA	70	70	NA	NA
Conversion Factor, CF	kg/mg	NA	NA	$1x10^{-6}$	$1x10^{-6}$	NA	NA
Absorbance Factor, ABS	unitless	Organics = 0.01; Inorganics = 0.001					

TABLE 6-9 (Continued)

SUMMARY OF EXPOSURE DOSE INPUT PARAMETERS
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Input Parameter	Units	Receptor					
		Current Trespasser Adolescent	Current Trespasser Adult	Current Adult Military Personnel	Future Construction Worker	Future Residential Child	Future Residential Adult
Groundwater							
Ingestion Rate, IR	L/d	NA	NA	NA	NA	1	2
Exposure Frequency, EF	d/y	NA	NA	NA	NA	350	350
Exposure Duration, ED	y	NA	NA	NA	NA	6	30
Exposure Time, ET	h/d	NA	NA	NA	NA	0.25	0.25
Surface Area, SA	cm^2	NA	NA	NA	NA	10,000	23,000
Averaging Time, Noncarc., ATnc	d	NA	NA	NA	NA	2,190	10,950
Averaging Time, Carc., ATcarc	d	NA	NA	NA	NA	25,550	25,550
Conversion Factor, CF	L/cm^3	NA	NA	NA	NA	0.001	0.001
Body Weight, BW	kg	NA	NA	NA	NA	15	70
Sediment							
Ingestion Rate, IR	mg/d	100	100	100	NA	200	100
Fraction Ingested, FI	unitless	1	1	1	NA	1	1
Exposure Frequency, EF	d/y	48	48	48	NA	48	48
Exposure Duration, ED	y	9	30	4	NA	6	30
Surface Area, SA	cm^2	3,480	5,800	4,300	NA	2,300	5,800
Absorption Factor, AF	mg/cm^3	1	1	1	NA	1	1
Averaging Time, Noncarc., ATnc	d	3,285	0	1,460	NA	2,190	10,950
Averaging Time, Carc., ATcarc	d	25,550	25,550	25,550	NA	25,550	25,550
Body Weight, BW	kg	37	70	70	NA	15	70
Conversion Factor, CF	kg/mg	$1x10^{-6}$	$1x10^{-6}$	$1x10^{-6}$	NA	$1x10^{-6}$	$1x10^{-6}$
Absorbance Factor, ABS	unitless	Organics = 0.01; Inorganics = 0.001					

TABLE 6-9 (Continued)

SUMMARY OF EXPOSURE DOSE INPUT PARAMETERS
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Input Parameter	Units	Receptor					
		Current Trespasser Adolescent	Current Trespasser Adult	Current Adult Military Personnel	Future Construction Worker	Future Residential Child	Future Residential Adult
Surface Water							
Ingestion Rate, IR	L/d	0.05	0.05	0.05	NA	0.05	0.05
Exposure Time, ET	h/d	2.6	2.6	2.6	NA	2.6	2.6
Exposure Frequency, EF	d/y	48	48	48	NA	48	48
Exposure Duration, ED	y	9	30	4	NA	6	30
Surface Area, SA	cm^2	3,480	5,800	4,300	NA	2,300	5,800
Body Weight, BW	kg	37	70	70	NA	15	70
Averaging Time, Noncarc., ATnc	d	3,285	10,950	1,460	NA	2,190	10,950
Averaging Time, Carc., ATcarc	d	25,550	25,550	25,550	NA	25,550	25,550
Conversion Factor, CF	L/cm^3	0.001	0.001	0.001	NA	0.001	0.001
Outdoor Air							
Inhalation Rate, IR	m^3/d	20	20	20	20	15	20
Exposure Frequency, EF	d/y	130	43	250	90	350	350
Exposure Duration, ED	y	9	30	4	1	6	30
Averaging Time, Noncarc., ATnc	d	3,285	10,950	1,460	365	2,190	10,950
Averaging Time, Carc,. ATcarc	d	25,550	25,550	25,550	25,550	25,550	25,550

TABLE 6-9 (Continued)

SUMMARY OF EXPOSURE DOSE INPUT PARAMETERS
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Input Parameter	Units	Receptor					
		Current Trespasser Adolescent	Current Trespasser Adult	Current Adult Military Personnel	Future Construction Worker	Future Residential Child	Future Residential Adult
Body Weight, BW	kg	37	70	70	70	15	70
Particulate Emission Factor, PEF[(1)]	m^3/kg	1.32E+09					

References:

USEPA Risk Assessment For Superfund Volume I. Human Health Manual (Part A) Interim Final, December, 1989.
USEPA Exposure Factors Handbook, July, 1989.
USEPA Risk Assessment For Superfund Volume I. Human Health Evaluation Manual Supplemental Guidance. "Standard Default Exposure Factors" Interim Final. March 25, 1991.
USEPA Dermal Exposure Assessment: Principles and Applications. Interim Report. January, 1992.
USEPA Region IV Guidance for Soil Absorbance. (USEPA, 1992)
USEPA Region III Risk-Based Concentration Table. October 20, 1995.
USEPA Region IV Supplemental Guidance to RAGS. November, 1995.

(1) To be published in the Final Soil Screening Level Guidance (USEPA, 1996)

Notes:

The exposure frequency for the trespasser receptors is based on the typical exposure pattern (i.e., more time spent outdoors in the warmer months vs. the cooler months) for people who actively garden or play outdoors. It is an upper-bound estimate (USEPA, 1992).

TABLE 6-10

SUMMARY OF EXPOSURE PATHWAYS
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Receptor	Exposure Pathway
Current Adult Military Personnel	Surface soil ingestion, dermal contact and inhalation of fugitive dusts Subsurface soil ingestion, dermal contact and inhalation of fugitive dusts Surface water ingestion and dermal contact Sediment ingestion and dermal contact
Current Adult and Child Trespassers	Surface soil ingestion, dermal contact and inhalation of fugitive dusts Surface water ingestion and dermal contact Sediment ingestion and dermal contact
Future Adult and Child Residents	Surface soil ingestion, dermal contact, and inhalation of fugitive dusts Subsurface soil ingestion, dermal contact, and inhalation of fugitive dusts Groundwater ingestion, dermal contact and inhalation Surface water ingestion and dermal contact Sediment ingestion and dermal contact
Future Construction Worker	Subsurface soil ingestion, dermal contact, and inhalation of fugitive dusts

TABLE 6-11

SUMMARY OF HEALTH-BASED CRITERIA
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

COPCs	RfD (Oral) (mg/kg/d)	RfC (Inhal.) (mg/kg/d)	CSF (Oral) $(mg/kg/d)^{-1}$	CSF (Inhal.) $(mg/kg/d)^{-1}$	Weight-of-Evidence
Pesticides					
4,4'-DDD	-	-	2.4E-01(i)	-	B2
4,4'-DDE	-	-	3.4E-01(i)	-	B2
4,4'-DDT	5.0E-04(i)	-	3.4E-01(i)	3.4E-01(i)	B2
alpha-Chlordane(1)	6.0E-05(i)	-	1.3E+00(i)	1.3E+00(i)	B2
gamma-Chlordane(1)	6.0E-05(i)	-	1.3E+00(i)	1.3E+00(i)	B2
Aroclor-1260	-	-	7.7E+00(i)	-	B2
Metals					
Aluminum	1.0E+00(e)	-	-	-	-
Antimony	4.00E-04(i)	-	-	-	D
Arsenic	3.0E-04(i)	-	1.5E+00(i)	1.5E+01(i)	A
Barium	7.0E-02(i)	1.4E-04(a)	-	-	D
Beryllium	5.0E-03(i)	-	4.3E+00(i)	8.4E+00(i)	B2
Chromium VI	5.0E-03(i)	-	-	4.2E+01(i)	D
Copper	4.0E-02(e)	-	-	-	D
Iron	3.0E-01(e)	-	-	-	-
Lead	-	-	-	-	B2
Manganese	2.4E-02(i)	1.4E-05(i)	-	-	D
Nickel	2.0E-02(i)	-	-	-	D
Vanadium	7.0E-03(h)	-	-	-	D
Zinc	3.0E-01(i)	-	-	-	D

Notes:

(1) Toxicity values for chlordane were substituted for this constituent.

References:

a = HEAST alternative
e = EPA-NCEA Regional Support Provisional Value
h = HEAST, 1994
i = IRIS, 1995
Region III RBC Table, October, 1995
- = Not available

TABLE 6-12

SUMMARY OF DERMALLY-ADJUSTED HEALTH-BASED CRITERIA*
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

COPCs	Percent Absorbed(1)	Oral RfD mg/kg/d	Oral RfD (Dermally-Adjusted) mg/kg/d	Oral CSF $(mg/kg/d)^{-1}$	Oral CSF (Dermally-Adjusted) $(mg/kg/d)^{-1}$
Pesticides					
4,4'-DDD	50%	--	--	2.40E-01	4.80E-01
4,4'-DDE	50%	--	--	3.40E-01	6.80E-01
4,4'-DDT	50%	5.00E-04	2.50E-04	3.40E-01	6.80E-01
alpha-Chlordane	50%	6.00E-05	3.00E-05	1.30E+00	2.60E+00
gamma-Chlordane	50%	6.00E-05	3.00E-05	1.30E+00	2.60E+00
Aroclor-1260	50%	--	--	7.7E+00	1.54E+01
Metals					
Aluminum	20%	1.00E+00	2.00E-01	--	--
Antimony	20%	4.00E-04	8.00E-05	--	--
Arsenic	20%	3.00E-04	6.00E-05	1.80E+00	7.50E+00
Barium	20%	7.00E-02	1.40E-02	--	--
Beryllium	20%	5.00E-03	1.00E-03	4.30E+00	2.15E+01
Chromium	20%	5.00E-03	1.00E-03	--	--
Copper	20%	4.00E-02	8.00E-03	--	--
Iron	20%	3.00E-01	6.00E-02	--	--
Lead	20%	--	--	--	--
Manganese	20%	2.40E-02	4.80E-03	--	--
Nickel	20%	2.00E-02	4.00E-03	--	--
Vanadium	20%	7.00E-03	1.40E-03	--	--
Zinc	20%	3.00E-01	6.00E-02	--	--

Notes:

(1) Region IV recommended values (i.e., 80% for VOCs, 50% for SVOCs/Pesticides, and 20% for Inorganics)

-- = Not Available
* = Only oral toxicity values were dermally adjusted; inhalation toxicity values were not adjusted.
Dermally-adjusted RfD = oral RfD*percent absorbed
Dermally-adjusted CSF = oral CSF/percent absorbed

References:

IRIS, 1995
HEAST, 1995
Region III RBC Table, October, 1995

TABLE 6-13

SUMMARY OF RISKS
CURRENT MILITARY RECEPTOR
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Exposure Pathway	Noncarcinogenic Risk	Carcinogenic Risk
Surface Soil		
Ingestion	0.02	1.0E-07
Dermal Contact	<0.01	2.9E-08
Inhalation	<0.01	1.3E-10
total	0.02	1.3E-07
Subsurface Soil		
Ingestion	0.08	4.0E-07
Dermal Contact	0.02	8.7E-08
Inhalation	<0.01	7.5E-09
total	0.1	5.0E-07
Surface Water		
Ingestion	<0.01	NA
Dermal Contact	<0.01	NA
total	<0.01	NA
Sediment		
Ingestion	<0.01	1.7E-08
Dermal Contact	<0.01	3.7E-09
total	<0.01	2.1E-08
Total Risk	0.12	6.5E-07

Notes:

NA - Not applicable. No carcinogenic COPCs selected.

TABLE 6-14

SUMMARY OF RISKS
CURRENT ADOLESCENT TRESPASSER
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Exposure Pathway	Noncarcinogenic Risk	Carcinogenic Risk
Surface Soil		
Ingestion	0.02	2.3E-07
Dermal Contact	<0.01	5.1E-08
Inhalation	<0.01	2.8E-10
total	0.02	2.8E-07
Surface Water		
Ingestion	<0.01	NA
Dermal Contact	<0.01	NA
total	<0.01	NA
Sediment		
Ingestion	0.01	7.2E-08
Dermal Contact	<0.01	1.3E-08
total	0.01	8.4E-08
Current Risk	0.03	3.7E-07

Notes:

NA = Not applicable. No carcinogenic COPCs selected.

TABLE 6-15

SUMMARY OF RISKS
FUTURE CHILD RESIDENT
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Exposure Pathway	Noncarcinogenic Risk	Carcinogenic Risk
Surface Soil		
Ingestion	0.2	2.0E-06
Dermal Contact	0.01	1.5E-07
Inhalation	<0.01	9.3E-10
total	0.21	2.2E-06
Groundwater		
Ingestion	**10**	8.5E-06
Dermal Contact	0.1	1.1E-07
Inhalation	--	--
total	**10**	8.6E-06
Surface Water		
Ingestion	0.01	NA
Dermal Contact	<0.01	NA
total	0.01	NA
Sediment		
Ingestion	0.04	2.4E-07
Dermal Contact	<0.01	1.4E-08
total	0.04	2.5E-07
Future Risk	**10**	1.1E-05

Notes:

-- = Not Applicable. No volatile organic COPCs selected.
NA = Not Applicable. No carcinogenic COPCs selected.
Bolded values indicate risk values that exceed the acceptable risk value of 1.0 for noncarcinogenic effects.

TABLE 6-16

SUMMARY OF RISKS
CURRENT ADULT TRESPASSER
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Exposure Pathway	Noncarcinogenic Risk	Carcinogenic Risk
Surface Soil		
Ingestion	<0.01	1.3E-07
Dermal Contact	<0.01	5.0E-08
Inhalation	<0.01	1.6E-10
total	<0.01	1.8E-07
Surface Water		
Ingestion	<0.01	NA
Dermal Contact	<0.01	NA
total	<0.01	NA
Sediment		
Ingestion	<0.01	1.3E-07
Dermal Contact	<0.01	3.8E-08
total	<0.01	1.6E-07
Current Risk	<0.01	3.4E-07

Notes:

NA = Not applicable. No carcinogenic COPCs selected.

TABLE 6-17

SUMMARY OF RISKS
FUTURE ADULT RESIDENT
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Exposure Pathway	Noncarcinogenic Risk	Carcinogenic Risk
Surface Soil		
Ingestion	0.02	1.1E-06
Dermal Contact	0.01	4.1E-07
Inhalation	<0.01	1.3E-09
total	0.03	1.5E-06
Groundwater		
Ingestion	**4.4**	1.8E-05
Dermal Contact	0.05	2.6E-07
Inhalation	--	--
total	**4.5**	1.8E-05
Surface Water		
Ingestion	<0.01	NA
Dermal Contact	<0.01	NA
total	<0.01	NA
Sediment		
Ingestion	<0.01	1.3E-07
Dermal Contact	<0.01	3.8E-08
total	<0.01	1.6E-07
Future Risk	**4.5**	2.0E-05

Notes:

-- = Not Applicable. No volatile organic COPCs selected.
NA = Not Applicable. No carcinogenic COPCs selected.
Bolded values indicate risk values that exceed the acceptable risk value of 1.0 for noncarcinogenic effects.

TABLE 6-18

SUMMARY OF RISKS
FUTURE CONSTRUCTION WORKER
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Exposure Pathway	Noncarcinogenic Risk	Carcinogenic Risk
Surface Soil		
Ingestion	0.03	4.5E-08
Dermal Contact	<0.01	2.0E-09
Inhalation	<0.01	1.1E-11
total	0.03	4.7E-08
Subsurface Soil		
Ingestion	0.14	1.7E-07
Dermal Contact	0.01	7.8E-09
Inhalation	<0.01	6.8E-10
total	0.15	1.8E-07
Future Risk	0.18	2.3E-07

TABLE 6-19

SUMMARY OF UNCERTAINTIES IN THE RESULTS
HUMAN HEALTH RISK ASSESSMENT
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

	Potential Magnitude for Over-Estimation of Risks	Potential Magnitude for Under-Estimation of Risks	Potential Magnitude for Over or Under-Estimation of Risks
Environmental Sampling and Analysis Sufficient samples may not have been taken to characterize the media being evaluated.			Low
Systematic or random errors in the chemical analysis may yield erroneous data.			Low
Selection of COPCs The use of USEPA Region III COPC screening concentrations in selecting COPCs in soil and groundwater.			Low
Exposure Assessment The standard assumptions regarding body weight, exposure period, life expectancy, population characteristics, and lifestyle may not be representative of the actual exposure situations.			Moderate
The use of the 95th percentile upper confidence level data of the lognormal distribution in the estimation of the RME.			Low
Assessing future residential property use when the likelihood of residential development is low.	High		
The amount of media intake is assumed to be constant and representative of any actual exposure.			Low
Toxicological Assessment Toxicological indices derived from high dose animal studies, extrapolated to low dose human exposure.	Moderate		
Lack of promulgated toxicological indices for inhalation pathway.		Low	
Risk Characterization Assumption of additivity in the quantitation of cancer risks without consideration of synergism, antagonism, promotion and initiation.			Moderate

TABLE 6-19 (Continued)

SUMMARY OF UNCERTAINTIES IN THE RESULTS
HUMAN HEALTH RISK ASSESSMENT
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

	Potential Magnitude for Over-Estimation of Risks	Potential Magnitude for Under-Estimation of Risks	Potential Magnitude for Over or Under-Estimation of Risks
Assumption of additivity in the estimation of systemic health effects without consideration of synergism, antagonism, etc.			Moderate
Additivity of risks by individual exposure pathways (dermal and ingestion and inhalation).	Low		Low
Compounds not quantitatively evaluated.		Low	

Notes:

Low = Assumptions categorized as "low" may effect risk estimates by less than one order of magnitude.

Moderate = Assumptions categorized as "moderate" may effect estimates of risk by between one and two orders of magnitude.

High = Assumptions categorized as "high" may effect estimates of risk by more than two orders of magnitude.

Source: Risk Assessment Guidance for Superfund, Volume 1, Part A: Human Health Evaluation Manual. USEPA, 1989a.

TABLE 6-20

TOTAL SITE RISK
SITE 63, VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Receptors	Surface Soil		Subsurface Soil		Groundwater		Surface Water/Sediment		Total	
	ICR	HI	ICR	HI	ICR	HI	ICR	HI	ICR	HI
Current Military Personnel	1.3E-07	0.02	5.0E-07	0.1	NA	NA	2.1E-08	<0.01	6.5E-07	0.12
Current Adolescent Trespasser	2.8E-07	0.02	NA	NA	NA	NA	8.4E-08	0.01	3.7E-07	0.03
Future Child Resident	2.2E-06	0.2	NA	NA	8.6E-06	**10**	2.5E-07	0.05	1.1E-05	**10**
Current Adult Trespasser	1.8E-07	<0.01	NA	NA	NA	NA	1.6E-07	<0.01	3.4E-07	<0.01
Future Adult Resident	1.5E-06	0.03	NA	NA	1.8E-05	**4.5**	1.6E-07	<0.01	2.0E-05	**4.5**
Future Construction Worker	4.7E-08	0.03	1.8E-07	0.15	NA	NA	NA	NA	2.3E-07	0.18

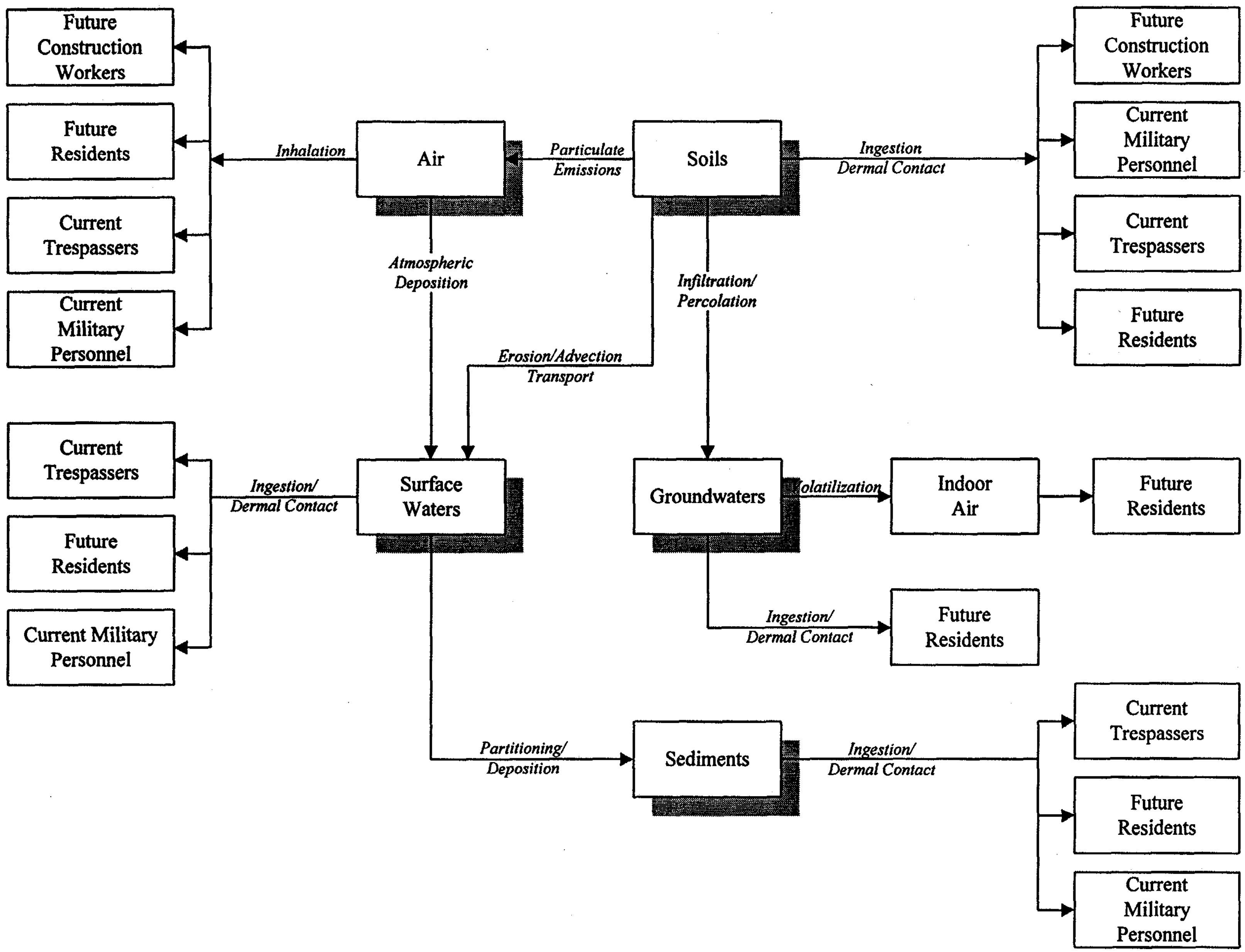
Notes:

ICR = Incremental Lifetime Cancer Risk
HI = Hazard Index
Total = Soil + Groundwater + Surface Water/Sediment
NA = Not Applicable
Bolded values indicate risk values that exceed the acceptable risk value of 1.0 for noncarcinogenic.

SECTION 6.0 FIGURES

FIGURE 6-1

FLOWCHART OF POTENTIAL EXPOSURE PATHWAYS AND RECEPTORS
SITE 63: VERONA LOOP DUMP



7.0 ECOLOGICAL RISK ASSESSMENT

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986, directs the United States Environmental Protection Agency (USEPA) to protect human health and the environment with respect to releases or potential releases of contaminants from abandoned hazardous waste sites (USEPA, 1989a). This section of the report presents the ecological risk assessment (ERA) conducted at Operable Unit No. 13 (Site 63) that assesses the potential impacts to ecological receptors from contaminants detected at this site.

7.1 Objectives, Scope, and Organization of the Ecological Risk Assessment

The objective of this ERA is to evaluate if past reported disposal practices at Site 63 are adversely impacting the terrestrial and aquatic communities on, or adjacent to, the site. This assessment also evaluates the potential effects of contaminants related to Site 63 on sensitive environments including wetlands and protected species. The conclusions of the ERA are used in conjunction with the human health risk assessment to evaluate the appropriate remedial action for this site for the overall protection of public health and the environment. If potential risks are characterized for the ecological receptors, further ecological evaluation of the site and surrounding areas may be warranted.

This ERA evaluated and analyzed the results from the Remedial Investigation (RI) including chemical analysis of the soil, groundwater, surface water, and sediment. Information used to evaluate sensitive environments was obtained from historical data and previous studies obtained in the literature or through conversations with appropriate state, federal, and local personnel.

The risk assessment methodologies used in this evaluation were consistent with those outlined in the Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (USEPA, 1994) and Framework for Ecological Risk Assessment (USEPA, 1992). In addition, information found in the following documents was used to supplement the USEPA guidance documents:

- USEPA Supplemental Risk Assessment Guidance for Superfund, Volume II, Environmental Evaluation Manual (USEPA, 1989b)

- Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference (USEPA, 1989c)

Based on the USEPA Framework for Ecological Risk Assessment, an ERA consists of three main components: 1) Problem Formulation; 2) Analysis, and, 3) Risk Characterization (USEPA, 1992). The problem formulation section includes a preliminary characterization of exposure and effects of the stressors to the ecological receptors. During the analysis phase, the data were evaluated to determine the exposure and potential effects on the ecological receptors from the stressors. Finally, in the risk characterization phase, the likelihood of adverse effects occurring as a result of exposure to a stressor is evaluated. This section also evaluates the potential impact to the ecological receptors at the site from the contaminants detected in the media. This ERA is organized to parallel these three components.

7.2 Problem Formulation

Problem formulation is the first step of an ERA and includes a preliminary characterization of exposure and effects (USEPA, 1992). Chemical analyses were performed on samples collected from the soil, groundwater, surface water, and sediment to evaluate the presence, concentrations, and variabilities of the contaminants. A habitat characterization also was conducted as part of the field activities. Based on these observations, potential ecological receptors were identified. Finally, toxicological information for the contaminants detected in the media was obtained from available references and literature and used to evaluate the potential adverse ecological effects to the ecological receptors.

The components of the problem formulation step include identifying the stressors and their potential ecological effects, identifying ecosystems potentially at risk, defining ecological endpoints, and presenting a conceptual model. The following sections discuss each of these components and how they were evaluated in this ERA.

7.3 Contaminants of Potential Concern

One of the initial steps in the problem formulation stage of an ERA is identifying the stressors and their potential ecological effects. For this ERA, the stressors that were evaluated include contaminants detected in the surface soil, surface water, and sediment.

Contaminants in the subsurface soil and groundwater were not evaluated in this ERA. Some terrestrial species burrow in the subsurface soil, and microorganisms most likely exist in the groundwater. However, current guidance does not provide sufficient information to evaluate risk to these receptors.

The nature and extent of contaminants detected in the environmental media at Site 63 are presented in Section 4.0 of this report. Sample locations were based on available historical site information and a site visit to evaluate potential ecosystems and ecological receptors.

7.3.1 Criteria for Selecting Contaminants of Potential Concern

Quantifying risk for all positively identified contaminants may distract from the dominant risk-driving contaminants at the site. Therefore, the data set is reduced to a list of contaminants of potential concern (COPCs). COPCs are site-related contaminants used to quantitatively estimate ecological exposures and associated potential ecological effects.

The criteria used in selecting the COPCs from the contaminants detected during the field sampling and analytical phase of the investigation are:

- Historical information
- Prevalence
- Toxicity
- Comparison to established screening values

- Comparison to investigation associated field and laboratory blank data
- Comparison to background or naturally occurring levels
- Comparison to anthropogenic levels

7.3.1.1 Historical Information

Historical information combined with the following selection procedures assists in the identification of the COPCs. The historical information for Site 63 is presented in Section 1.0 of this report. To be conservative, contaminants detected in the surface soil, surface water, and sediment that may not have been historically used at the site were retained as COPCs to evaluate risk, but may be eliminated in the ecological significance section as not being site-related.

7.3.1.2 Prevalence

The frequency of positive detections in sample sets and the level at which a contaminant is detected in a given medium are factors that determine a chemical's prevalence. Prevalence is discussed in more detail in Section 6.2. Contaminants that were detected in five-percent or fewer of the samples were not retained as COPCs.

7.3.1.3 Toxicity

The potential toxicity of a contaminant is an important consideration when selecting COPCs for further evaluation in the ERA. Several of the contaminants detected in the media at Site 63 were prevalent. However, the inherent toxicity of some of the contaminants to ecological receptors is low (e.g., calcium, magnesium, potassium, and sodium); and therefore, they were not retained as COPCs. In addition, several of the contaminants have not been adequately studied to develop published toxicity values, or even accepted toxicological data with which to assess the contaminants. Contaminants that fall into this category were retained as COPCs (if they were not eliminated based upon other criteria); however, they were not quantitatively evaluated in the ERA.

7.3.1.4 Established Screening Values

There are no state or federal soil screening values that can be used to evaluate potential ecological risks to terrestrial receptors (other than plants or invertebrates). Therefore, toxicity of contaminants in the surface soil to terrestrial receptors was not used as criteria for retaining COPCs except for calcium, magnesium, potassium, and sodium, which were not retained as COPCs in any of the media.

Surface soil screening values (SSSVs) were obtained from Oak Ridge National Laboratory (ORNL) (Will and Suter, 1994a,b) and USEPA Region III (USEPA, 1995a). ORNL has developed benchmark screening values for plants, invertebrates, earthworms, microorganisms, and microbial processes. The USEPA Region III Biological Technical Assistance Group has developed SSSVs for the protection of flora and fauna. Most of the inorganic SSSVs used in this ERA were developed by ORNL, while most of the organic SSSVs were developed by USEPA Region III.

North Carolina Water Quality Standards (NCWQS) for surface water have been developed (NC DEHNR, 1996). In addition to the NCWQS, Water Quality Screening Values (WQSVs) have been developed by USEPA Region IV (USEPA, 1995b), USEPA Region III (USEPA, 1995a), and

ORNL (Suter and Mabrey, 1994). The NCWQS and WQSVs will be herein referred to as Surface Water Screening Values (SWSVs).

Sediment quality standards have not been developed for North Carolina. However, Sediment Screening Values (SSVs) are available for many contaminants. These SSVs include Sediment Screening Levels (SSLs) (Long et al. 1995; Long and Morgan, 1991; and, USEPA, 1995a), calculated sediment quality criteria (SQC) (USEPA, 1993a), Apparent Effect Threshold values (Tetra-Tech, Inc., 1986), and Wisconsin Department of Natural Resources interim guidance criteria for in-water disposal of dredged sediments (Sullivan, et al., 1985).

The SWSVs and SSVs were used for comparative purposes to infer potential ecological risks. Contaminants that were detected at concentrations less than these screening values were not retained as COPCs for aquatic receptors since contaminants detected at concentrations less than these values are not expected to pose a significant risk to the aquatic receptor population. However, contaminants in the surface water below SWSVs may still be retained as COPCs for the terrestrial receptors. None of the contaminants in the sediment were retained as COPCs for the terrestrial receptors because current guidance does not exist to evaluate this pathway.

A brief explanation of the standards, criteria, and screening values used for the evaluation of the COPCs is presented below:

North Carolina Water Quality Standards (Surface Water) - NCWQS are the concentrations of toxic substances that will not result in chronic toxicity to aquatic life (NC DEHNR, 1996). NCWQS are provided for both freshwater and saltwater aquatic systems.

USEPA Water Quality Screening Values (WQSVs) - WQSVs are non-enforceable regulatory guidelines and are of primary utility in assessing acute and chronic toxic effects in aquatic systems. WQSVs are provided for both freshwater and saltwater aquatic systems and are reported as acute and/or chronic values (USEPA, 1995a, b). Most of the WQSVs are the same as the USEPA Ambient Water Quality Criteria (AWQC) (USEPA, 1991a); however, some of the WQSVs are based on more current studies.

Oak Ridge National Laboratory (ORNL) Aquatic Benchmarks - ORNL Aquatic Benchmarks are developed for many contaminants, including those that do not have NCWQS or WQSVs (Suter and Mabrey, 1994). The ORNL aquatic benchmarks include secondary acute values and secondary chronic values that are calculated using the Tier II method described in the EPA's Proposed Water Quality Guidance for the Great Lakes System (USEPA, 1993b). Tier II values are developed so that aquatic benchmarks could be established with fewer data than are required for the USEPA AWQC. The benchmarks are limited to contaminants in freshwater.

Sediment Screening Levels - Sediment Screening Levels (SSLs) have been compiled to evaluate the potential for contaminants in sediments to cause adverse biological effects (Long et al, 1995; Long and Morgan, 1991; and, USEPA, 1995a). The lower ten percentiles (Effects Range-Low [ER-L]) and the median percentiles (Effects Range-Median [ER-M]) of biological effects have been developed for several contaminants. The concentration below the ER-L represents a minimal-effects range (adverse effects would be rarely observed). The concentration above the ER-L but below the ER-M represents a possible-effects range (adverse effects would occasionally occur). Finally, the concentration above the ER-M represents a probable-effects range (adverse effects would probably occur).

In addition to the SSLs, Apparent Effects Threshold Sediment Quality Values have been developed by Tetra Tech Inc. (1986) for the Puget Sound. These values are the concentrations of contaminants above which statistically significant biological effects would always be expected. Finally, the Wisconsin Department of Natural Resources has developed interim criteria for in-water disposal of dredged sediments (Sullivan et al., 1985). However, these criteria are established using background data and are not based on aquatic toxicity. They only were used when no other sediment criteria are available for a contaminant.

Sediment Quality Criteria - Currently, promulgated SQC only exist for a few contaminants. However, SQC for nonionic organic compounds can be calculated using the procedures in the Technical Basis for Deriving Sediment Quality Criteria for Nonionic Organic Contaminants for the Protection of Benthic Organisms by using Equilibrium Partitioning (USEPA, 1993a) as follows:

SQC = (Foc)(Koc)(FCV)/1,000,000

Where:

SQC = sediment quality criteria (µg/kg)
Foc = sediment organic carbon content (mg/kg)
Koc = chemical organic carbon partition coefficient (mL/g)
FCV = final chronic water quality value (µg/L)

7.3.1.5 Field and Laboratory Blank Data

Associating contaminants detected in field-related blanks (i.e., trip blanks, equipment rinsates, and/or field blanks) or laboratory method blanks with the same contaminants detected in analytical samples can eliminate non-site-related contaminants from the list of COPCs. Blank data should be compared to sample results with which the blanks are associated. However, for this data set it is difficult to associate specific blanks with specific environmental samples. Thus, in order to evaluate detection levels, maximum contaminant concentrations reported in a given set of blanks were applied to a corresponding set of samples.

In accordance with the National Functional Guidelines for Organics (USEPA, 1991b), common lab contaminants (i.e., acetone, 2-butanone, methylene chloride, toluene, and phthalate esters) should be regarded as a direct result of site activities only when sample concentrations exceed the maximum blank concentration by ten. For other contaminants not considered common in a lab, concentrations exceeding five times the maximum blank concentration indicate contamination resulting from site activities (USEPA, 1991b). Maximum concentrations of contaminants detected in blanks are presented in Section 6.0, Table 6.1.

Contract Required Quantitation Limits (CRQLs) and percent moisture are employed when evaluating contaminant concentrations in soil, in order to correlate solid and aqueous detection limits. For example, the CRQL for semivolatiles in soil is 33 to 66 times that of aqueous samples, depending on the contaminant. In order to assess semivolatile contaminant levels in soil using aqueous blanks, the blank concentration must then also be multiplied by 33 or 66 to account for variance from the CRQL (common lab contaminants must first be multiplied by five or ten, as explained in the paragraph above). The final value is divided by the sample percent moisture.

Eliminating a sample result correlates directly to a reduction in the contaminant prevalence in that medium. Consequently, if elimination due to blank concentration reduces the prevalence of a contaminant to less than five-percent, a contaminant that may have been included according to its prevalence is eliminated as a COPC.

7.3.1.6 Background or Naturally Occurring Levels

Contaminants that were detected in the surface soil at concentrations less than two-times the average base-background concentration were not retained as COPCs. As presented in Section 4.0, off-site surface water and sediment samples were collected from several water bodies in the White Oak River basin (refer to Appendix Q). Contaminants detected in the off-site samples were compared to contaminants detected in the on-site samples to determine if contaminant concentrations in the site stations were below naturally occurring regional levels.

A small channeled freshwater stream was sampled at Site 63. Therefore, the freshwater (upstream) off-site background surface water and sediment samples were compared to the Site 63 samples to determine if contaminant concentrations were within background concentrations. Contaminants that were detected among Site 63 surface water or sediment samples at concentrations less than the average background concentrations were not retained as COPCs.

7.3.1.7 Anthropogenic Levels

Ubiquitous anthropogenic background concentrations result from non-site related sources such as combustion of fossil fuels (i.e., automobiles) and industrial facilities. Examples of ubiquitous, anthropogenic chemicals are polycyclic aromatic hydrocarbons (PAHs). Anthropogenic chemicals are typically not eliminated as COPCs without considering other selection criteria. It is difficult to determine that such chemicals are present at the site because of operations not related to the site or the surrounding area. Omitting anthropogenic background chemicals from the risk assessment may result in the loss of important information for those potentially exposed.

The following sections apply the aforementioned selection criteria beginning with the prevalence of detected analytical results in each medium of interest to establish a preliminary list of COPCs for Site 63. Once this task has been completed, a final list of media-specific COPCs will be selected based on the remaining criteria.

7.3.2 Selection of Contaminants of Potential Concern

The following sections present an overview of the analytical data obtained for each medium during the RI and the subsequent retention or elimination of COPCs using the aforementioned selection criteria. Contaminants that were not eliminated based on the above criteria were retained as COPCs. The primary reasons for retaining contaminants as COPCs include, but may not be limited to the following: (1) frequently detected, (2) detected at concentrations above the screening values (if available) and/or (3) detected at concentrations above background (if available). In addition, some common laboratory contaminants (i.e., phthalates, acetone, 2-butanone) were retained as COPCs if they were detected frequently and were detected at levels slightly less than ten times the concentration in the blank samples. Calcium, magnesium, potassium, and sodium were not retained as COPCs in any of the media because they are naturally occurring, are not related to the site, and no published toxicity data was identified to assess potential impacts to aquatic or terrestrial life.

Table 7-1 presents the selection of the surface soil COPCs based on frequency of detection and comparison to twice the base-background concentrations. Table 7-2 compares surface water contaminant concentrations to the SWSVs and the average off-site background sample contaminant concentrations. Table 7-3 presents the comparison of the sediment contaminant concentrations to applicable SSVs and the average off-site background sample contaminant concentrations. A summary of the COPCs in each medium is presented in Table 7-4. All of the media samples were analyzed for Target Compound List (TCL) volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), pesticides, polychlorinated biphenyls (PCBs), and Target Analyte List (TAL) inorganics.

7.3.2.1 Surface Soil

Forty-six surface soil samples were collected at Site 63. As depicted in Table 7-1, two VOCs (acetone and methylene chloride) were detected in the surface soil. However, acetone and methylene chloride were not retained as COPCs because they are common laboratory contaminants and they were detected at less than ten times the concentration in the blank samples.

Three SVOCs were detected in the surface soil: bis(2-ethylhexyl)phthalate, di-n-butyl phthalate, and n-nitrosodiphenylamine. No SVOCs were retained as COPCs because they were detected at less than ten times the concentration in the blank samples, were detected infrequently, or are known to be common laboratory contaminants.

Seven pesticides and one PCB were detected in the surface soil: alpha-chlordane, gamma-chlordane, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, dieldrin, endosulfan sulfate, and Aroclor-1260. Dieldrin, 4,4'-DDE, 4,4'-DDT, and endosulfan sulfate were retained as surface soil COPCs. The remaining compounds were eliminated as COPCs because they were infrequently detected.

Twenty-two inorganics were detected in the surface soil. Aluminum, arsenic, barium, beryllium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, and zinc were retained as surface soil COPCs. Calcium, magnesium, potassium, and sodium were not retained as COPCs due to their low toxicity characteristics. Antimony, selenium, and vanadium were not retained as COPCs because they were detected at concentrations less than twice base background concentrations. In addition, cadmium and silver were not retained as surface soil COPCs because they were infrequently detected.

7.3.2.2 Surface Water

Five surface water samples were collected at Site 63. As displayed in Table 7-2, one VOC (acetone) and one SVOC [bis(2-ethylhexyl)phthalate] were detected in the surface water. Neither contaminant was retained as a COPC for the aquatic and terrestrial receptors because they are common laboratory contaminants and were detected at concentrations less than ten times the concentration in the blank sample. No pesticides or PCBs were detected in the surface water.

Nine inorganics were detected in the surface water. Iron, manganese, and zinc were not retained as COPCs for the aquatic receptors because detected concentrations did not exceed SWSVs. However, iron, manganese, and zinc were retained as COPCs for terrestrial receptors because they were detected above background concentrations. Aluminum, barium, and lead were retained as COPCs for both aquatic and terrestrial receptors. Calcium, magnesium, and sodium were eliminated as COPCs based on their low toxicity.

7.3.2.3 Sediment

Five sediment samples were collected at Site 63. At each station, sediment samples were collected from a depth of 0 to 6 inches. As displayed on Table 7-3, no VOCs or SVOCs were detected in the sediment. Five pesticides were detected in the sediment and four were retained as COPCs: alpha-chlordane, gamma-chlordane, 4,4'-DDD, and 4,4'-DDE. The compound 4,4'-DDT was not retained as a COPC because it did not exceed the average reference station concentration.

Sixteen inorganics were detected in the sediment. Calcium, magnesium, potassium, and sodium were not retained as COPCs based on their low toxicity. Arsenic, barium, beryllium, chromium, copper, iron, lead, manganese, nickel, and zinc were not retained as COPCs because they did not exceed their respective SSVs. Aluminum and vanadium were the only inorganics retained as COPCs in the sediment.

7.3.3 Physical/Chemical Characteristics of COPCs

Physical and chemical characteristics of contaminants may affect their mobility, transport, and bioavailability in the environment. These characteristics include bioconcentration factors (BCFs), organic carbon partition coefficient (K_{oc}), octanol water partition coefficient (K_{ow}), and biotransfer factors (Bv, Bb, Br). Table 7-5 summarizes these values for the COPCs detected in the surface soil, surface water, and sediment. Information from this table is used to assess the fate and transport of the constituents and the potential risks to the environmental receptors at the site. The following paragraphs discuss the significance of each parameter included in the table.

BCFs measure the tendency for a chemical to partition from the water column or sediment and concentrate in aquatic organisms. BCFs are important for ecological receptors because chemicals with high BCFs could accumulate in lower-order species and subsequently accumulate to toxic levels in species higher up the food chain. The BCF is the concentration of the chemical in the organism at equilibrium divided by the concentration of the chemical in the water. Therefore, the BCFs are unitless. The BCF is used to determine if a contaminant has a high potential to bioaccumulate in aquatic or terrestrial organisms.

K_{oc} measures the tendency for a chemical to partition between soil and sediment particles containing organic carbon and water. This coefficient is important in the ecological environment because it determines how strongly an organic chemical will bind to the organics in the sediments. The K_{oc} is used to calculate sediment quality criteria.

K_{ow} is the ratio of a chemical concentration in octanol divided by the concentration in water. The octanol/water partition coefficient has been shown to correlate with BCFs in aquatic organisms and with adsorption to soil or sediment. The K_{ow} is used to calculate the plant biotransfer factors that are used to estimate the COPC concentration in plants that would potentially be ingested by the terrestrial receptors in the intake model.

The plant biotransfer factors (Bv or Br) measure the potential for a chemical to accumulate in a plant. These factors are used to calculate the concentration of the COPCs in either the leafy part of the plant (Bv) or the fruit of the plant (Br). The factors for inorganics are obtained from Baes et al.

(1984), while the factors for organics are calculated according to Travis and Arms, (1988). The Bv and Br values for the organics are assumed to be same value.

Finally, the beef biotransfer factors (Bb) measure the potential for a chemical to accumulate in an animal. This factor is used to calculate the COPC concentration in the small mammal that is ingested by the red fox. The factors for inorganics are obtained from Baes et al. (1984), while the factors for organics are calculated according to Travis and Arms (1988).

7.4 Ecosystems Potentially at Risk

Ecological receptors that may potentially be at risk from contaminants at Site 63 were identified during the field investigations. Information regarding regional and site-specific ecology is presented in Section 2.0. Based on the results of the field investigations, potential receptors of contaminants in surface water and sediment include fish, benthic macroinvertebrates, other aquatic flora and fauna and some terrestrial faunal species. Potential receptors of contaminants in soil include deer, rabbits, foxes, raccoons, birds, other terrestrial fauna, and terrestrial flora.

7.5 Ecological Endpoints

The information compiled during the first stage of problem formulation (stressor characteristics and ecosystems potentially at risk) is used to select the ecological endpoints for this ERA. The following section presents the ecological endpoints selected for this ERA and the reasons they were selected.

There are two primary types of ecological endpoints: assessment endpoints and measurement endpoints. Assessment endpoints are environmental characteristics, which, if they are found to be significantly affected, may indicate a need for remediation. Measurement endpoints are quantitative expressions of an observed or measured effect of the COPCs. Measurement endpoints may be identical to assessment endpoints, or they may be used as surrogates for assessment endpoints.

A measurement endpoint, or "ecological effects indicator" as it is sometimes referred, is used to evaluate the assessment endpoint. Therefore, measurement endpoints must correspond to, or be predictive of, assessment endpoints. In addition, they must be readily measurable, preferably quickly and inexpensively, using existing techniques. Measurement endpoints must take into consideration the magnitude of the contamination and the exposure pathway. The measurement endpoint should be an indicator of effects that are temporally distributed. Low natural variability in the endpoint is preferred to aid in attributing the variability in the endpoint to the contaminant. Measurement endpoints should be diagnostic of the pollutants of interest, as well as broadly applicable to allow comparison between sites and regions. Also, measurement endpoints should be standardized (e.g., standard procedures for toxicity tests). Finally, it is desirable to use endpoints that already are being measured (if they exist) to determine baseline conditions.

Both types of endpoints were used in the ecological risk evaluation and are discussed in the following subsections.

7.5.1 Aquatic Endpoints

The assessment endpoint for the aquatic portion of this ERA is the potential decrease in the aquatic receptor population or subpopulation that is attributable to site-related contaminants. The measurement endpoint for this aquatic assessment endpoint is the exceedence of contaminant-specific surface water and sediment effect concentrations (i.e., SWSVs, and SSVs). Section 7.8 (Ecological Effects Characterization) discusses the contaminant-specific surface water and sediment effect concentrations and Section 7.11 (Uncertainty Analysis) discusses the limitation of their use in this ERA.

7.5.2 Terrestrial Endpoints

The assessment endpoint for the terrestrial receptors is the potential reduction of a receptor population or subpopulation that is attributable to site-related contaminants. The measurement endpoints for the terrestrial ERA include exceedences of contaminant-specific soil effect concentrations (i.e., SSSVs) and of contaminant-specific effect doses. The contaminant specific effect doses were used in the chronic daily intake (CDI) models for terrestrial species. Section 7.8 (Ecological Effects Characterization) discusses contaminant-specific soil effect concentrations and contaminant-specific effect doses and Section 7.11 (Uncertainty Analysis) discusses the limitation of their use in this ERA.

7.6 Conceptional Model

This section of the ERA presents each potential exposure pathway via soil, groundwater, surface water, sediment, and air, and the likelihood that an exposure will occur through these pathways. Figure 7-1 presents the flowchart of potential exposure pathways and ecological receptors.

To determine if ecological exposure via these pathways may occur in the absence of remedial actions, an analysis is conducted including the identification and characterization of the exposure pathways. The following four elements were examined to determine if a complete exposure pathway is present:

- A source and mechanism of chemical release
- An environmental transport medium
- A feasible receptor exposure route
- A receptor exposure point

The following subsections discuss the potential exposure scenarios at Site 63 including exposure to surface soil, groundwater, surface water, sediment, and air.

7.6.1 Soil Exposure Pathway

Potential release sources to be considered in evaluating the soil pathway are surface or buried wastes and contaminated soil. The release mechanisms to be considered are fugitive dust, leaching, tracking, and surface runoff. The transport medium is the soil. The potential routes to be considered for ecological exposure to the contaminated soil are ingestion and dermal contact. Potential exposure points for ecological receptors include species living in or coming in contact with the soil. COPCs were detected in the surface soil, demonstrating a release from a source to the surface soil transport medium. Potential receptors that may be exposed to contaminants in surface soil at/or around Site 63 may include the following: deer, foxes, raccoons, rabbits, birds, plants, and other terrestrial life.

Terrestrial receptors potentially are exposed to contaminants in the soil through ingestion, dermal contact, and/or direct uptake (for flora). The magnitude of the exposure depends on their feeding habits and the amount of time they reside in the contaminated soil. In addition, terrestrial species may ingest organisms that have bioconcentrated contaminants from the soil. This exposure pathway is likely to occur at Site 63 and, therefore, was retained for further analysis.

7.6.2 Groundwater Exposure Pathway

The potential release source to be considered in evaluating the groundwater pathway is contaminated soil. The release mechanism to be considered is leaching. The routes to be considered for ecological exposure to the contaminated groundwater are ingestion and dermal contact. Groundwater discharge to area surface waters may represent a pathway for contaminant migration.

Subsurface biota (i.e., microorganisms) are the only ecological receptors expected to be directly exposed to groundwater. Potential impacts to the biota were not assessed in this ERA because current guidance does not provide sufficient information to evaluate risk. The groundwater to surface water exposure is accounted for in the surface water section of the ERA.

7.6.3 Surface Water and Sediment Exposure Pathway

Potential release sources to be considered in evaluating the surface water and sediment pathways are surface soil and groundwater. The release mechanisms to be considered are groundwater seepage and surface runoff. The potential routes to be considered for ecological exposure to the contaminated surface water/sediment are ingestion and dermal contact. Potential exposure points for ecological receptors include species living in or coming in contact with the surface water/sediment on-site. COPCs were detected in the surface water and sediment demonstrating a release from a source to the surface water or sediment transport medium. Potential receptors that may be exposed to contaminants in surface water and sediment include: fish, benthic macroinvertebrates, deer, birds, and other aquatic and terrestrial life.

Aquatic receptors are exposed to contaminants in the surface water and sediment by ingesting water while feeding and by direct contact while feeding or swimming. This exposure pathway is likely to occur at Site 63 and is evaluated in the ERA. In addition, aquatic organisms may ingest other aquatic flora and fauna that have bioaccumulated chemicals from the surface water and sediment. This potential exposure pathway was not evaluated in the ERA because current guidance does not provide sufficient information to evaluate risk.

Terrestrial faunal receptors potentially are exposed to contaminants in the surface water and sediment through ingestion and dermal contact. The magnitude of the exposure depends on their feeding habits and the amount of time they reside in the contaminated waters. In addition, terrestrial species may ingest organisms (e.g., fish, small mammals, invertebrates, and plants) that have bioconcentrated contaminants from the surface water and sediment. These exposure pathways are likely to occur at Site 63. However, only the surface water and surface soil ingestion pathways were evaluated in the ERA for terrestrial receptors. Current guidance does not exist to evaluate the sediment pathway, subsurface soil pathway, or dermal contact pathway for terrestrial receptors; therefore, these pathways were not evaluated in the ERA.

7.6.4 Air Exposure Pathway

There are two potential release mechanisms to be considered in evaluating the atmospheric pathway: release of contaminated particulates and volatilization from surface soil, groundwater, and surface water. The potential exposure points for receptors are areas on or adjacent to the site. The air exposure pathway was not evaluated in this ERA because air sampling was not conducted, and current guidance does not provide sufficient information to evaluate risk.

7.7 <u>Exposure Assessment</u>

The exposure assessment evaluates the interaction of stressors (COPCs) with the ecological receptors. The RI included collecting samples for analytical analysis from four media; soil, groundwater, surface water, and sediment. As presented earlier in the ERA, contaminants in the subsurface soil and groundwater were not evaluated. The analytical results for the data used in ERA are presented in Section 4.0 of this report.

The regional ecology, site ecology, and habitat characterization in the areas surrounding Site 63 are presented in Section 3.0 of this report. Information on sensitive environments and endangered species also is included in this section.

Exposure of terrestrial flora and fauna (invertebrates and microorganisms) to contaminants in the surface soil was assumed to be equal to the contaminant concentration in the surface soil. It is noted in the uncertainty section of this ERA that all the contaminants detected in the surface soil may not be bioavailable to the terrestrial flora or fauna. Exposure of aquatic receptors to contaminants in the surface water and sediment was assumed to be equal to the contaminant concentration detected in the surface water and sediment. Exposure of other terrestrial fauna (mammals, birds) to contaminants in the surface soil and surface water was estimated using the chronic daily intake models presented in the next section of this ERA.

The following sections present the results of the ecosystem characterization including the surface water, sediment, abiotic habitat, and biotic habitat.

7.7.1 Surface Water and Sediment Sampling

Field water quality measurements (including temperature, pH, specific conductance, and dissolved oxygen) were collected during the sampling event prior to the surface water and sediment sample collection.

The station locations and sampling procedures for collecting the environmental media are presented in Section 2.0 of this report.

7.7.1.1 <u>Abiotic Habitat</u>

The stream at Site 63 is an intermittent freshwater tributary to the tidally influenced Mill Creek. The stream ranged from 2 to 12 inches in depth and 2 to 4 feet in width. The sediment characterization for each sampling site is presented on Table 7-6. The sediment was primarily sand at each station. Table 7-7 presents the results of the field chemistry including the temperature, pH, dissolved oxygen concentration, and conductivity. The temperature ranged from 12.2 to 14.8 °C; conductivity ranged from 68.9 to 89.1 µmhos/cm; the dissolved oxygen ranged from 4.3 to 7.5 mg/L; and the pH ranged from 3.62 to 3.99 standard units. The low pH at Site 63 is probably a result of the pine needles from the surrounding forest being deposited in the stream bed, lowering the pH.

7.7.1.2 Biotic Habitat

The biotic habitat was not investigated in this ERA. Because of the small size and intermittent nature of the stream at Site 63, it is unlikely that a large, healthy population of fish or benthic macroinvertebrates would inhabit this area. Mosquitofish and tolerant benthic macroinvertebrate species are most likely the only faunal species that may inhabit this drainage area.

7.8 Ecological Effects Characterization

The ecological effects data that were used to assess potential risks to aquatic and/or terrestrial receptors in this ERA include aquatic and terrestrial screening values as presented in Section 7.3.1.4 to aid in the selection of the COPCs. Terrestrial effects also were assessed by using available terrestrial reference values (TRVs). The following subsections present a summary of the ecological effects comparison.

7.8.1 Surface Water

Contaminant concentrations detected in the surface water at Site 63 were compared to the freshwater SWSVs to determine if there were any exceedences of the published values (see Table 7-2). Aluminum, barium, and lead were the only contaminants detected in the surface water that exceeded any of the SWSVs.

The SWSVs for barium (69.1 µg/L-acute, 3.8 µg/L-chronic) are the ORNL aquatic benchmarks (Suter and Mabrey, 1994). These values appear to be overly conservative since the lowest chronic value for aquatic organisms (daphnids) was 5,800 µg/L (Suter and Mabrey, 1994). In addition, it is reported in the Quality Criteria for Water-1986 that soluble barium concentrations in fresh waters generally would have to exceed 50,000 µg/L before toxicity to aquatic life would be expected (USEPA, 1987). Therefore, the maximum barium concentration in the surface water samples (26.4 µg/L) is below the concentrations that are expected to cause adverse impacts to aquatic life. Lead was detected in a surface water field blank sample, indicating that sample contamination may be influencing the surface water concentrations. The maximum lead sample concentration (2.2 µg/L) was detected below five times the blank concentration. Therefore, lead should have been eliminated from the surface water COPC list. However, to be conservative, it was retained as a COPC.

7.8.2 Sediment

Contaminant concentrations detected in the sediment at Site 63 were compared to SSVs and calculated SQC values to determine if there were any exceedences of the published values (see Table 7-3). The pesticides, alpha-chlordane, gamma-chlordane, 4,4'-DDD, and 4,4'-DDE were the only organics that exceeded SSVs. Most of these pesticides only exceeded the ER-L. Only gamma-chlordane exceeded its ER-M value.

Aluminum and vanadium were the only inorganics that were retained as COPCs. Neither one of these inorganic compounds have established SSVs that can be used to evaluate the potential toxicity of the contaminants to aquatic life.

7.8.3 Surface Soil

Surface soil was evaluated in this ERA by the comparison of the surface soil COPC concentrations to established flora and fauna benchmark values for plants, earthworms, invertebrates, microorganisms, and microbial processes. In addition, surface soil was evaluated by the calculation of terrestrial CDI models. The following subsections describe the use of the SSSVs and CDI models to evaluate the surface soil collected at Site 63.

7.8.3.1 Comparison to Surface Soil Screening Values

Toxicity values used for surface soil comparisons are benchmark values; therefore, these values represent a concentration at which no or low toxic effects are observed. It is noted that surface soil concentrations may exceed one or two benchmark values, but still support vigorous and diverse flora and fauna communities (Will and Suter, 1994a, b). Soil toxicity data cannot be used to evaluate potential risks to other terrestrial fauna (i.e., birds, deer, and rabbits) because the exposure doses for these species are different than the exposure doses for invertebrates and plants, which are in constant direct contact with the contaminants in the soil.

As displayed on Table 7-8, one pesticide and several inorganics were detected in the surface soil samples at concentrations above the SSSVs. The pesticide 4,4'-DDT exceeded the SSSV in five samples. The inorganics, with the number of exceedences in parentheses include: aluminum (46), iron (46), chromium (44), zinc (4), copper (3), lead (3), manganese (2), and mercury (1).

7.8.3.2 Terrestrial Chronic Daily Intake Model

In addition to comparing the soil concentrations to toxicity values for terrestrial invertebrates and plants, a terrestrial intake model was used to estimate exposure of terrestrial receptors to the COPCs (Scarano and Woltering, 1993). The following presents the procedures used to evaluate the potential soil exposure (both direct and indirect) of terrestrial fauna at Site 63 to COPCs via surface water, soil, and food chain transfer.

Based on the regional ecology and potential habitat at the site, the indicator species used in this analysis were the white-tailed deer, cottontail rabbit, red fox, raccoon, and the bobwhite quail. The exposure points for these receptors were the surface soil, surface water, and biota. The routes for terrestrial exposure to the COPCs in the soil and water are ingestion of incidental soil, drinking water, vegetation (leafy plants, seeds, and berries), fish, and small mammals.

7.8.3.3 Derivation of Terrestrial Reference Value

Total exposure of the terrestrial receptors to the COPCs in the soil and surface water was determined by estimating the CDI dose and comparing this dose to TRVs representing acceptable daily doses in milligrams per kilograms per day (mg/kg/day). The TRVs were developed from No-Observed-Adverse-Effect-Levels (NOAELs) or Lowest-Observed-Adverse-Effect-Levels (LOAELs) obtained from the Integrated Risk Information System (IRIS), Agency for Toxic Substances and Disease Registry Toxicological Profiles, mineral tolerance levels of domestic animals (NAS, 1992), or other toxicological data in the literature. Appendix R presents the methodology used in deriving the TRVs and the animals that were used to derive each TRV.

7.8.3.4 Calculation of Chronic Daily Intake

Potential impacts to the terrestrial receptors from the COPCs detected in the soil and surface water were determined by estimating the CDI dose and comparing this dose to TRVs representing acceptable daily doses in mg/kg/day. The estimated CDI dose of the bobwhite quail, cottontail rabbit, white-tailed deer, and small mammal, to soil, surface water, and vegetation was determined using the following equation:

$$CDI = \frac{(Cw)(Iw) + [(Cs)(Bv)(Iv) + (Cs)(Is)][H]}{BW}$$

Where:

CDI	= Chronic Daily Intake, mg/kg/d
Cw	= Contaminant concentration in the surface water, mg/L
Iw	= Rate of drinking water ingestion, L/d
Cs	= Contaminant concentration in soil, mg/kg
Bv	= Soil to plant transfer coefficient (leaves, stems, straw, etc.), unitless
Iv	= Rate of vegetation ingestion, kg/d
Is	= Incidental soil ingestion, kg/d
H	= Contaminated area/Home range area ratio, unitless
BW	= Body weight, kg

To calculate the contaminant concentration in the small mammal, the resulting CDI from the above equation is multiplied by the biotransfer factor for beef (Bb) for organics (Travis and Arms, 1988) and metals (Baes et al., 1984).

The estimated CDI dose of the raccoon is determined using the following equation.

$$CDI = \frac{(Cw)(Iw) + (Cf)(If) + [(Cs)(Br)(Iv) + (Cs)(Is)][H]}{BW}$$

where:

CDI	= Chronic Daily Intake, mg/kg/d
Cw	= Contaminant concentration in the surface water, mg/L
Iw	= Rate of drinking water ingestion, L/d
Cf	= Contaminant concentration in the fish, mg/kg [Cw * BCF]
If	= Rate of fish ingestion, kg/d
Cs	= Contaminant concentration in soil, mg/kg
Br	= Soil to plant transfer coefficient (fruit, seeds, tubers, etc.), unitless
Iv	= Rate of vegetation ingestion, kg/d
Is	= Incidental soil ingestion, kg/d
H	= Contaminated area/Home range area ratio, unitless
BW	= Body weight, kg

The estimated CDI dose of the red fox is determined using the following equation:

$$CDI = \frac{(Cw)(Iw) + [(Cs)(Bv)(Iv) + (Cs)(Is) + (Cm)(Im)][H]}{BW}$$

where:

CDI	= Chronic Daily Intake, mg/kg/d
Cw	= Contaminant concentration in the surface water, mg/L
Iw	= Rate of drinking water ingestion, L/d
Cs	= Contaminant concentration in soil, mg/kg
Bv	= Soil to plant transfer coefficient (leaves, stems, straw, etc.), unitless
Iv	= Rate of vegetation ingestion, kg/d
Is	= Incidental soil ingestion, kg/d
Cm	= Contaminant concentrations in small mammals, mg/kg
Im	= Rate of small mammal ingestion, kg/d
H	= Contaminated area/Home range area ratio, unitless
BW	= Body weight, kg

Bioconcentration of the COPCs to plants was calculated using the soil to plant transfer coefficient (Bv or Br) for organics (Travis and Arms, 1988) and metals (Baes et al., 1984). The concentrations of the COPCs used in the models were the log of the upper 95-percent confidence limit or the maximum detected concentration. The exposure parameters used in the CDI calculations are presented in Table 7-9.

7.9 Risk Characterization

The risk characterization is the final phase of a risk assessment. It is at this phase that the likelihood of adverse effects occurring as a result of exposure to a stressor is evaluated. This section evaluates the potential decrease in aquatic and terrestrial populations at Site 63 from contaminants identified at the site.

A Quotient Index (QI) approach was used to characterize the risk to aquatic receptors from exposure to surface water and sediments and terrestrial receptors from exposure to surface soil, surface water, and biota. This approach characterizes the potential effects by comparing exposure levels of COPCs in the surface water and sediments to the aquatic reference values presented in Section 7.8, Ecological Effects Characterization. The QI was calculated as follows:

$$QI = \frac{(EC,\ CDI)}{(SWSV,\ SSV,\ TRV)}$$

Where:

QI	= Quotient Index
EC	= Exposure Concentration, µg/L, µg/kg or mg/kg
CDI	= Chronic Daily Intake, mg/kg/day
SWSV	= Surface Water Screening Value, µg/L
SSV	= Sediment Screening Value, µg/kg or mg/kg
TRV	= Terrestrial Reference Value, mg/kg/day

A QI greater than "unity" (one) is considered to be indicative of potential risk. Such values do not necessarily indicate that an effect will occur but only that a lower threshold has been exceeded. However, it is important to determine which contaminants are posing the highest risks, in order to evaluate the significance of those contaminants to the site. Therefore, the evaluation of the significance of the QI has been judged as follows: (Menzie et al., 1993)

- QI exceeds one but less than 10: some small potential for environmental effects.
- QI exceeds 10: significant potential that greater exposures could result in effects based on experimental evidence.
- QI exceeds 100: effects may be expected since this represents an exposure level at which effects have been observed in other species.

The risks characterized above provide insight into general effects upon animals and plants in the local population. However, depending on the endpoint selected, they may not indicate if population-level effects will occur.

7.9.1 Surface Water

Table 7-10 presents the surface water QIs calculated per station and Table 7-11 presents the surface water QIs calculated per COPC. The QIs for the hardness-dependent metals were calculated using a sample-specific hardness value.

A hardness of 25.0 mg/L calcium carbonate ($CaCO_3$) was used to calculate the hardness-dependent SWSVs for the inorganic compounds (lead and zinc) in Section 7.3.2. Station specific hardness values ranged from 7.24 to 7.89 mg/L; therefore, a default of 25.0 mg/L was used in the criteria calculations because the hardness values were below 25 mg/L (Federal Register, 1992).

In summary, the aluminum and barium chronic SWSV QIs were between 5 and 10 for each of the samples. Chronic SWSV lead QIs were between 1 and 5. The QIs calculated with the WQS and acute SWSV values all were below 1. As displayed on Table 7-11, the QIs calculated for chronic SWSV per COPC, using the average concentrations were greater than 5 for aluminum and barium. It is noted that UCL values were not used in the cumulative QI calculations because of the small size of the sample set. The chronic cumulative lead QI is between 1 and 5. Total surface water QIs for Site 63 were less than 1 for WQS values (0.05), slightly above 1 one for the acute SWSVs (1.31), and greater than 10 for the chronic SWSVs (16.28). It is noted that the SWSV for barium appears to be extremely conservative based on other literature sources. Also, as previously noted, lead was detected in the surface water field blanks. Therefore, the concentrations of barium and lead in the surface water are not expected to significantly decrease the population of aquatic receptors.

7.9.2 Sediment

Table 7-12 presents the sediment QIs calculated per station and Table 7-13 presents the sediment QIs calculated per sediment COPC that exceed 1.

Only gamma-chlordane slightly exceeded the ER-M (QI = 1.03) value. ER-L QIs greater than 5 were calculated at one station (63-SD04) for alpha-chlordane (QI = 9.40), gamma-chlordane (QI = 12.4) and 4,4'-DDD (QI = 5.50). ER-L QIs for 4,4'-DDD and 4,4'-DDE at Station 63-SD03 were calculated between 1 and 5. As presented on Table 7-13, cumulative sediment QIs indicate a potential risk to the aquatic receptor population from pesticides detected in the sediment. QIs calculated with the average concentration for each COPC demonstrated ER-L QIs between 1 and 5 for alpha- and gamma- chlordane, 4,4'-DDD, and 4,4'-DDE. Cumulative QIs were greater than 10 for the ER-L (11.33) and less than 1 for the ER-M (0.98) and the SQC (0.66). It is noted that UCL values were not used to calculate cumulative sediment QIs because of the small sample set.

7.9.3 Terrestrial Chronic Daily Intake Model

Table 7-14 contains the terrestrial receptor QIs calculated for the surface soil and surface water COPCs at Site 63. The QIs calculated for the red fox, bobwhite quail, and the white-tail deer were all below 1. The QI for the cottontail rabbit (2.00) indicates a small potential for environmental effects. The QI for the raccoon (12.3) was between 10 and 100, indicating a significant potential that greater exposure could result in effects. The risk to the rabbit is driven by aluminum, barium, iron, and zinc. Risk to the raccoon is driven by aluminum. The calculations for the Site 63 terrestrial models are presented in Appendix R.

7.9.4 Threatened and Endangered Species

A natural heritage resource survey conducted at Camp Lejeune (LeBlond et al., 1994) identified the following rare and endangered species as potentially inhabiting Site 63 or the surrounding area: Bachman's sparrow (Aimophila aestivalis) (a federal candidate endangered species and a state species of special concern) and Cooper's hawk (Accipiter cooperii). In addition, one federal candidate endangered plant species, Chapman's sedge (Carex chapmanni) is known to exist in the area of Site 63. A state candidate endangered species, drooping bulrush (Scirpus lineatus) also may potentially inhabit Site 63.

7.9.5 Wetlands

Site-specific wetland delineations were not conducted at Site 63. The National Wetland Inventory (NWI) maps identified wetlands in the proximity of Site 63. COPCs detected in surface water and sediment may be affecting the wetland areas. It should be noted that no areas of stressed or dead vegetation were observed during the field investigations.

7.9.6 Sensitive Environments

As presented on Figure 2-7, a sensitive area (Mill Run Swamp) was identified in close proximity to Site 63 by a natural resource survey conducted at MCB, Camp Lejeune (LeBlond et al., 1994). Only the intermittent tributary at Site 63 is included in the identified sensitive area. Ecological receptors present within the study area; however, are not expected to be significantly impacted by the concentrations of COPCs detected in the surface soil, surface water, and sediment.

7.10 Ecological Significance

This section essentially summarizes the overall risks to the ecology at the site. It addresses potential impacts to the ecological receptors at Site 63 from the COPCs detected in the media and evaluates which COPCs are impacting the site to the greatest degree. This information, to be used in conjunction with the human health risk assessment, supports the selection of remedial action(s) for Site 63 that are protective of human health and the environment.

7.10.1 Aquatic Endpoints

As presented earlier in the ERA, the assessment endpoint for the aquatic receptors is the potential decrease in the aquatic receptor population or subpopulation that is attributable to site-related contaminants. The measurement endpoint for this aquatic assessment endpoint is the exceedence of contaminant-specific surface water and sediment effect concentrations (i.e., SWSVs, and SSVs).

Based on the risk characterization, there is a slight potential for aluminum, barium, and lead detected in the surface water to affect aquatic life. However, the screening level used to evaluate barium concentrations was very conservative and lead was detected in a blank sample. In addition, the consistent concentrations of aluminum at each sampling station are most likely due to the low surface water pH at the site. Natural waters with pH levels below 4.0 may contain several hundred or even several thousand milligrams of aluminum per liter (Hem, 1992). It is noted that aluminum and barium were detected at higher concentrations in the surface water collected during the Site Inspection conducted at Site 63 in 1991 (Baker, 1994).

Based on the risk characterization, there only is a slight potential for pesticide compounds (chlordane, 4,4'-DDD, and 4,4'-DDE) detected in the sediment to cause a decrease in the aquatic population. It is noted that the pesticides in the sediment were detected primarily at one station, 63-SD04. In addition, only one pesticide exceeded the ER-M. It is noted that the pesticides detected at Site 63 are most likely a result of past, base-wide pesticide applications.

It is noted that because of the intermittent and shallow nature of this stream, other factors may be stressing the aquatic environment. The shallowness of the stream subjects the surface water to low dissolved oxygen concentrations and high temperatures both of which may adversely affect aquatic organisms. Also, the naturally occurring low pH impacts the aquatic environment.

7.10.2 Terrestrial Endpoints

As presented earlier in the ERA, the assessment endpoints for the terrestrial receptors are the potential reduction of a receptor population or subpopulation that is attributable to contaminants from the site. The first measurement endpoint is to determine if there are exceedences of contaminant-specific soil effect concentrations (i.e., SSSVs).

Several contaminants were detected in the surface soil at concentrations that exceeded the SSSVs. The greatest number of exceedances of the SSSVs were from aluminum, chromium, and iron. Therefore, there is the potential for a decrease in the population of terrestrial plants and invertebrates at Site 63. There are two rare plant species that potentially may inhabit the Site 63 area and that may be adversely impacted by COPC concentrations detected in the surface soil. However, the only contaminants that exceeded flora values were aluminum, chromium, iron, lead, and zinc. The confidence levels for the aluminum and chromium values are very low, based on a low number of studies conducted. The confidence levels for the lead and zinc values are moderate. Finally, the origin of the iron value is not known. It is not known if the COPCs in the surface soil will impact the rare plant species at Site 63, since there is uncertainty associated with the SSSVs. In addition, locations of the rare plant species have not been verified on Site 63. No visible signs of stressed or dead vegetation in these areas were observed during the field investigations.

The second measurement endpoint is to determine if the terrestrial CDI exceeds the TRVs. The CDI versus the TRV for the red fox, bobwhite quail, and the white-tail deer was less than one. The QIs for the cottontail rabbit and the raccoon exceeded one. It is noted that the individual QIs for each COPC in the rabbit model were below one. However, the cumulative QI for the rabbit model slightly exceeded one. Aluminum, barium, iron, and zinc are the primary risk drivers in the rabbit model. Aluminum is the risk driver in the raccoon model. The use of a relatively high aluminum BCF to calculate estimated fish tissue concentrations contributed to the high QI for the raccoon model. Because of the small channel size and shallow depth of the sampling stream, it is unlikely that there are enough fish in this stream to supply a raccoon with 60 percent of its diet as represented in the model.

7.11 Uncertainty Analysis

The procedures used in this evaluation to assess risks to ecological receptors, as in all such assessments, are subject to uncertainties. The following discusses some of the uncertainty in this ERA associated with sampling methodology, screening levels, and terrestrial models.

7.11.1 Sampling Methodology

The chemical sampling program at Site 63 consisted of five surface water and sediment samples. Because there were fewer than twenty samples, contaminants could not be eliminated because of infrequency. Therefore, contaminants not related to the site may have been retained as COPCs and thus carried through the ERA.

7.11.2 Screening Levels

There is uncertainty in the ecological endpoint comparison. The SWSVs (NCWQS and AWQC) are established to be protective of a majority of the potential receptors. However, some species will not be protected by the values because of their increased sensitivity to the chemicals. For example, the Ambient Water Quality Criteria developed by the USEPA in theory only protects 95 percent of the exposed species. Therefore, there may be some sensitive species present that may not be protected by these criteria. In addition, most of the values are established using laboratory tests, where the concentrations of certain water quality parameters (pH, hardness, TOC) that may influence toxicity are most likely at different concentrations in the site water.

Potential adverse impacts to aquatic receptors from contaminants in the sediments were evaluated by comparing the COPC concentration in the sediments to SSVs. These SSVs have more uncertainty associated with them than do the SWSVs, since the procedures for developing them are not as established as those used in developing SWSVs. In addition, sediment type (pH, acid volatile sulfide, total organic carbon) also has a significant impact on the bioavailability and toxicity of contaminants.

Potential adverse impacts to terrestrial invertebrates and plants were evaluated by comparing the COPC concentration in the soil to SSSVs. Most of these studies do not take into account soil type, which may have a large influence on the toxicity of the contaminants. For example, soil with high organic carbon content will tend to sorb many of the organic COPCs, thus making them less bioavailable to terrestrial receptors. Also, various inorganic compounds in surface soil tend to have high degrees of variability. The variability of the inorganic concentrations in the surface soil in turn magnifies that uncertainty associated with using the literature toxicity values to assess the risk posed to terrestrial flora and fauna.

The benchmark values are based on both field and growth chamber studies; therefore, the reported toxic concentrations are not always equivalent to actual field concentrations. In addition, the majority of the benchmark values used for comparison purposes are based on a low number of studies on a limited diversity of test species, which greatly adds to the uncertainty of these values.

The toxicity of chemical mixtures is not well understood. All the toxicity information used in the ERA for evaluating risk to the ecological receptors is for individual chemicals. Chemical mixtures can affect the organisms very differently than the individual chemicals due to synergistic or antagonistic effects. In addition, the species that were used to develop the toxicity data may not be present at the site or have the potential to exist at the site. Depending on the sensitivity of the tested species to the species at the site, use of the toxicity values may overestimate of underestimate risk. Many chemicals are not acutely toxic; however, they have the potential to bioaccumulate in ecological receptors through food chain transfer. This bioaccumulation potential typically is not taken into account when comparing contaminant concentrations to screening values.

Finally, toxicological data for several of the COPCs are limited or do not exist. Therefore, there is uncertainty in any conclusions involving the potential impacts to aquatic receptors from these contaminants.

7.11.3 Terrestrial Models

There are some differences of opinion found in the literature as to the effectiveness of using models to predict concentrations of contaminants found in terrestrial species. According to one source, the food chain models currently used incorporate simplistic assumptions that may not represent actual site conditions, bioavailability of contaminants, or site-specific behavior of the receptors. Simple food chain models can provide an effective means of initial characterization of risk; however, residue analyses, toxicity tests, and the use of biomarkers provide a better approach for assessing exposure (Menzie et al., 1993).

There are several sources of uncertainty when using these models. First, most of the terrestrial reference values are based on toxicity data from another species, which is then extrapolated to the species of concern using a body-size scaling equation. Since the toxicity of all contaminants may not be proportional to body size, the calculated TRVs may not accurately predict risk to the species of concern. Another source of uncertainty with the models is that many of the input parameters are based on default values (i.e., ingestion rate) that may or may not adequately represent the actual values of the parameters. In addition, there is uncertainty in the amount that the indicator species will represent other species potentially exposed to COPCs at the site.

It is noted that there is uncertainty with use of the raccoon model to access terrestrial risks at Site 63. Risk to the raccoon was demonstrated by aluminum. The aluminum risk is primarily the result of the hypothetical calculation of the fish tissue concentration (surface water concentration multiplied by the BCF). The BCF for aluminum is a high number therefore, resulting in a high concentration for fish tissue. The model assumes that 60 percent of the raccoon's diet is derived from the fish in the study tributary. Because of the intermittent and shallow nature of this tributary, it is unlikely that the fish present could sustain 60 percent of a raccoon's diet. Therefore, risk to the raccoon at Site 63 may be biased high.

There is uncertainty in use of the bioconcentration and biotransfer factors. Bioconcentration and biotransfer factors can vary widely from species to species. The species used in the calculation of the bioconcentration and biotransfer factors are different than the species that actually occur at the site. Therefore, use of the factors will tend to either overestimate or underestimate actual bioaccumulation of contaminants. Finally, terrestrial receptors also may be exposed to contaminants in the sediments. However, currently, there is no guidance in the literature that can be used to evaluate this potential exposure pathway.

7.12 <u>Conclusions</u>

The following subsections provide an overview of potential risks to the ecological environment identified at Site 63 during this assessment. Potential risks to the aquatic environment at Site 63 are demonstrated by the cumulative QI ratios greater than 1 calculated for both surface water and sediment. In addition, potential risks to the terrestrial environment are demonstrated by exceedances of soil toxicity values and risk exhibited in terrestrial CDI models. However, the significance of the potential risks is considered to be low based on this ERA.

7.12.1 Aquatic Ecosystem

Surface water concentrations of aluminum, barium, and lead may be adversely impacting the aquatic environment in the freshwater stream at Site 63. Cumulative QI ratios were calculated for the surface water at 1.31 for acute and 16.28 for chronic. These inorganic COPCs were detected at relatively the same concentrations at each sampling location. However, due to the conservative barium criteria and lead in the blank sample, aluminum appears to be the only COPC potentially impacting the aquatic environment. It is noted that aluminum and barium were detected at higher concentrations during the 1991 Site Inspection (Baker, 1994). In addition, aluminum dissolves readily into surface water under acidic conditions and the pH concentrations detected at Site 63 surface water stations were below four. Therefore, the low pH levels are elevating the concentrations of aluminum detected in the surface water.

The potential risk to the aquatic community posed by the sediment is demonstrated by cumulative QI value of 11.33 for the ER-L. It is noted that risk is not demonstrated by the cumulative QI values calculated for the ER-M (0.98) and SQC (0.66) values. The risk to the aquatic environment from the sediment is due to concentrations of chlordane, 4,4'-DDD, and 4,4'-DDE. However, these pesticides are not site-related contaminants, but rather a result of base-wide pesticide control programs.

It is noted that the intermittent, shallow nature of the stream also contributes to stresses to the aquatic environment. The shallowness of the stream subjects the surface water to low DO concentrations and high temperatures both of which may adversely impact many aquatic organisms.

7.12.2 Terrestrial Ecosystem

Overall, some potential impacts to soil flora and fauna may occur as a result of concentrations of aluminum, chromium, copper, iron, lead, manganese, mercury, and zinc detected in the surface soil at Site 63. It should be noted that there is much uncertainty in the use of the flora and fauna SSSVs. In addition, the inorganics with the most exceedances of the SSSVs (aluminum, chromium, and iron) also exceed SSSVs for the background concentrations, indicating that regional conditions contribute to the potential risk to the terrestrial flora and fauna.

The terrestrial intake models only demonstrated a significant risk greater than one for the raccoon model. This risk was driven by concentrations of aluminum in the surface water via bioconcentration in fish tissue. It is noted that background surface water concentrations of aluminum also may generate a risk in the raccoon model. Therefore, regional conditions are contributing to the terrestrial risk to the vertebrate population at Site 63.

7.13 References

Arthur and Alldredge. 1979. Public Health Evaluation and Ecological Assessment. Martin Marrietta Astronautics Group, Waterton Facility, Vol. II of III, Appendix A and B. Cited in Scarano and Woltering, 1993.

Agency for Toxic Substances and Disease Registry (ATSDR). 1993. Toxicological Profile for Endosulfan. Prepared by Clement Associates for the US Department of Health and Human Services.

Baes, C.F., Sharp, A.L., and R.W. Shor. 1984. "Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture." Oak Ridge National Laboratory. September 1984.

Baker. Baker Environmental, Inc. 1994. Site Inspection Report - Site 63, Verona Loop Dump. final. Prepared for the Department of the Navy, Naval Facilities Engineering Command, Atlantic Division, Norfolk, Virginia. January 1994.

Beyer, N., E. Connor, and S. Gerould. 1993. "Estimates of Soil Ingestion by Wildlife". Patuxent Wildlife Research Center, Laurel, Maryland.

Dee, J.C. 1991. "Methodology For Assessing Potential Risks To Deer Populations: A Case Study at a Superfund Site". Paper presented at the 1991 Annual Meeting of the Society of Environmental Toxicology and Chemistry. Abstract No. 426. November 1991.

Federal Register. December 22, 1992. Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants; States' Compliance; Final Rule. 40 CFR Part 131, pp. 60848-60923.

Fitchko, J. 1989. Criteria for Contaminated Soil/Sediment Cleanup. Pudvan Publishing Company, Northbrook, Illinois.

Hem, J.D. 1992. Study and Interpretation of the Chemical Characteristics of Natural Waters. U.S. Geological Survey Water-Supply Paper 2254. U.S. Department of the Interior.

Hulzebos, E.M., Adema, D.M.M., Dirven-van Breemen, E.M., Henzen, L., Van Dis, W.A., Herbold, H.A., Hoekstra, J.A., Baerselman, R., and Van Gestel, C.A.M. 1993. "Phytotoxicity Studies with *Lactuca sativa* in Soil and Nutrient Solution". Environmental Toxicology and Chemistry. Vol. 12, No. 6:1079-1094.

LeBlond, R., J. Fussel., and A. Braswell. 1994. "Inventory of the Rare Species, Natural Communities, and Critical Areas of the Camp Lejeune Marine Corps Base, North Carolina." For the North Carolina Natural Heritage Program, Division of Parks and Recreation, Department of Environment, Health, and Natural Resources. February 1994.

Long, E.W., D.D. Macdonald, S.L. Smith, and F.D. Calder. 1995. "Incidence of Adverse Biological Effects within Ranges of Chemical Concentrations in Marine and Estuarine Sediments." Environmental Management. Vol. 19, No.1, pp. 81-97.

Long, E.R and Morgan, L.G. 1991. "The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program." National Oceanic and Atmospheric Administration Technical Memorandum NOS OMA 52.

Menzie, C.A., Cura J. and J. Freshman. 1993. "Evaluating Ecological Risks and Developing Remedial Objectives at Forested Wetland Systems in New England." Paper contained in: Application of Ecological Risk Assessment To Hazardous Waste Site Remediation. Water Environmental Federation. January 1993.

Nagy, Kenneth. 1987. "Field Metabolic Rate and Food Requirement Scaling in Mammals and Birds. Ecological Monographs." 57(2). pp. 111-128.

NAS. National Academy of Sciences. 1992. Mineral Tolerance of Domestic Animals. Subcommittee on Mineral Toxicity in Animals. Washington, D.C. pp 5-7.

NC DEHNR. North Carolina Department of Health and Natural Resources. 1996. 15A NCAC 2b.0200 - Classifications and Water Quality Standards Applicable to Surface Waters of North Carolina. January 1, 1996.

NC DEHNR. North Carolina Department of Health and Natural Resources. 1993. Classifications and Water Quality Standards Assigned to the Waters of the White Oak River Basin. February 1, 1993.

Opresko, D.M., B.E. Sample, and G.W. Suter II. 1994. Toxicological Benchmarks for Wildlife, 1994 Revisions. Prepared for the US Department of Energy, Office of Environmental Restoration and Waste Management. ES/ER/TM-86/R1. September 1994.

Scarano, Louis, J. Ph.D. and Daniel M. Woltering, Ph.D. 1993. "Terrestrial and Aquatic Eco-Assessment for A RCRA Hazardous Waste Site". Paper contained in: Application of Ecological Risk Assessment To Hazardous Waste Site Remediation. Cited in WEF. January 1993.

SCDM. Superfund Chemical Data Matrix. 1991. Superfund Chemical Data Matrix. United States Environmental Protection Agency Hazardous Site Evaluation Division. December 1991.

Sullivan, J., J. Ball, E. Brick, S. Hausmann, G., G. Pilarski, and D. Sopcich. 1985 Report of the Technical Subcommittee on Determination of Dredge Material Suitability for In-Water Disposal. Wisconsin Department of Natural Resources, Madison, Wisconsin. November 1985.

Suter, G.W. II. and J.B. Mabrey. 1994. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1994 Revision. Environmental Sciences Division, Oak Ridge National Laboratory.

Tetra Tech, Inc. 1986. Development of Sediment Quality Values for Puget Sound, Volume I. Puget Sound Dredged Disposal Analysis Report. Cited in Fitchko, 1989.

Travis, Curtis C. and Angela Arms. 1988. Bioconcentration of Organics in Beef, Milk, and Vegetation. Environmental Science Technology. Vol. 22, No. 3.

USEPA. United States Environmental Protection Agency. 1995a. "Region III BTAG Screening Levels". Region III, Philadelphia, Pennsylvania. January 19, 1995.

USEPA. United States Environmental Protection Agency. 1995b. "Toxic Substance Spreadsheet". Region IV, Atlanta, Georgia. January 26, 1995.

USEPA. United States Environmental Protection Agency. 1994. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments. Environmental Response Team, Edison, New Jersey. September 26, 1994.

USEPA. United States Environmental Protection Agency. 1993a. Technical Basis for Deriving Sediment Quality Criteria for Nonionic Organic Contaminants for the Protection of Benthic Organisms by using Equilibrium Partitioning. Office of Water. EPA-822-R-93-011. September 1993.

USEPA. United States Environmental Protection Agency. 1993b. "Water Quality Guidance for the Great Lakes System and Correction: Proposed Rules". Federal Register. 58(72) 20802-21047. Cited in Suter and Mabrey, 1994.

USEPA, United States Environmental Protection Agency. 1993c. Sediment Quality Criteria for the Protection of Benthic Organisms- Dieldrin. Office of Science and Technology. Health and Ecological Criteria Section. Washington, D.C. September 1993.

USEPA. United States Environmental Protection Agency. 1993d. Wildlife Exposure Factors Handbook. Office of Research and Development. Washington, D.C. EPA/600/R-93/187a. December 1993.

USEPA. United States Environmental Protection Agency. 1992. Framework for Ecological Risk Assessment. Risk Assessment Forum. EPA/630/R-92/001. October 1993.

USEPA. United States Environmental Protection Agency. 1991a. "Water Quality Criteria Summary" (Wall Chart). Office of Science and Technology. Health and Ecological Criteria Section. Washington, D.C. May 1, 1991.

USEPA. United States Environmental Protection Agency. 1991b. National Functional Guidelines for Organic Data Review. Draft. USEPA Contract Laboratory Program. June 1991.

USEPA. United States Environmental Protection Agency. 1989a. Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A). Interim Final EPA/540/1-89/002. December 1989.

USEPA. United States Environmental Protection Agency. 1989b. Risk Assessment Guidance for Superfund Volume II. Environmental Evaluation Manual Interim Final. Office of Solid Waste and Emergency Response. Washington, D.C. EPA/540/1-89-001. March 1989.

USEPA. United States Environmental Protection Agency. 1989c. Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference. Environmental Research Laboratory, Corvallis, OR. EPA/600/3-89/013. March 1989.

USEPA. United States Environmental Protection Agency. 1987. Quality Criteria for Water-1986. Office of Water Regulations. May 1987.

USEPA. Unites States Environmental Protection Agency. 1986. Chemical, Physical, and Biological Properties of Compounds Present at Hazardous Waste Sites. Office of Solid Waste and Remedial Response. Washington D.C. EPA/540/1-86/060. October 1986.

Will, M.E. and Suter, G.W. II. 1994a. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process. Environmental Sciences Division, Oak Ridge National Laboratory.

Will, M.E. and Suter, G.W. II. 1994b. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Terrestrial Plants. Environmental Sciences Division, Oak Ridge National Laboratory.

SECTION 7.0 TABLES

TABLE 7-1

**FREQUENCY AND RANGE OF CONTAMINANT DETECTIONS
COMPARED TO SURFACE SOIL BACKGROUND VALUES
SITE 63 - VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA**

Contaminant	Twice the Average Background Surface Soil Concentration	Contaminant Frequency/Range		Ecological COPC?	Comments
		No. of Positive Detects/No. of Samples	Range of Positive Detections		
Volatiles (µg/kg)					
Acetone	NZ	1/46	11J	No	Lab Contaminant/Infrequently Detected
Methylene Chloride	NZ	3/46	14-34J	No	Lab Contaminant
Semivolatiles (µg/kg)					
Bis(2-ethylhexyl)phthalate	NZ	7/45	41J-4,400	No	Lab Contaminant
Di-n-butylphthalate	NZ	1/45	78J	No	Infrequently Detected
N-Nitrosodiphenylamine	NZ	1/45	51J	No	Infrequently Detected
Pesticides/PCBs (µg/kg)					
Aroclor-1260	NZ	2/45	28J-97	No	Infrequently Detected
alpha-Chlordane	NZ	2/45	3.5-16	No	Infrequently Detected
gamma-Chlordane	NZ	2/45	2.7J-9	No	Infrequently Detected
4',4-DDD	NZ	2/45	12-26J	No	Infrequently Detected
4',4-DDE	NZ	7/45	2.7J-55J	Yes	
4',4-DDT	NZ	11/45	2J-50J	Yes	
Dieldrin	NZ	3/46	3J-4.1J	Yes	
Endosulfan Sulfate	NZ	4/45	1.9J-2.8J	Yes	

TABLE 7-1 (Continued)

FREQUENCY AND RANGE OF CONTAMINANT DETECTIONS
COMPARED TO SURFACE SOIL BACKGROUND VALUES
SITE 63 - VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Twice the Average Background Surface Soil Concentration	Contaminant Frequency/Range		Ecological COPC?	Comments
		No. of Positive Detects/No. of Samples	Range of Positive Detections		
Inorganics (mg/kg)					
Aluminum	5,941	46/46	268J-7,050J	Yes	
Antimony	5.34	8/40	2.1J-4.3J	No	Below Background
Arsenic	1.31	36/46	0.32-3.7	Yes	
Barium	17.36	46/46	3-53.1	Yes	
Beryllium	0.21	5/46	0.1J-0.27	Yes	
Cadmium	0.69	2/46	1-3.1	No	Infrequently Detected
Calcium	1,397	36/46	10.4-2,780J	No	Low Toxicity
Chromium	6.69	44/46	1.1-11.1	Yes	
Cobalt	1.92	7/46	0.49-4.3	Yes	
Copper	7.20	29/46	0.47-74.8	Yes	
Iron	3,755	46/46	590-22,400J	Yes	
Lead	23.75	46/46	2.6-107	Yes	
Magnesium	205.75	46/46	28.4-223	No	Low Toxicity
Manganese	18.50	46/46	3.4J-348J	Yes	
Mercury	0.09	4/46	0.06-0.21J	Yes	
Nickel	3.43	33/46	0.62J-9.8	Yes	
Potassium	199.6	36/46	18.9J-349	No	Low Toxicity

TABLE 7-1 (Continued)

FREQUENCY AND RANGE OF CONTAMINANT DETECTIONS
COMPARED TO SURFACE SOIL BACKGROUND VALUES
SITE 63 - VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Twice the Average Background Surface Soil Concentration	Contaminant Frequency/Range		Ecological COPC?	Comments
		No. of Positive Detects/No. of Samples	Range of Positive Detections		
Inorganics (mg/kg)					
Selenium	0.75	2/46	0.27-0.33	No	Infrequently Detected/Below Background
Silver	0.88	2/46	0.72-0.97	No	Infrequently Detected
Sodium	59.30	7/46	5.3-100	No	Low Toxicity
Vanadium	11.63	44/46	2-11	No	Below Background
Zinc	13.88	36/46	0.98-1,860	Yes	

NZ = Not Analyzed

TABLE 7-2

FREQUENCY AND RANGE OF CONTAMINANT DETECTIONS
COMPARED TO SURFACE WATER SCREENING VALUES
SITE 63 - VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Water Screening Values (SWSV)			Average Reference Station Concentration	Contaminant Frequency/Range		No. of Positive Detects Above Lowest SWSV	No. of Positive Detects Above the Average Reference Station Concentration	Ecological COPC?	Comments
	North Carolina Water Quality Standards (WQS)(1)	USEPA Region IV Water Quality Screening Values (WQSV)								
		Acute	Chronic		No. of Positive Detects/ No. of Samples	Range of Positive Detections				
Volatiles (µg/L)										
Acetone	NE	9,000,000(4)	11,200(5)	ND	1/5	11J	0	1	No	Lab Contaminant
Semivolatiles (µg/L)										
Bis(2-ethylhexyl)phthalate	NE	286(5)	30.0(4)	ND	1/5	100	1	1	No	Lab Contaminant
Inorganics (µg/L)										
Aluminum	NE	750(2)	87(2)	333	5/5	602-688	5	5	Yes	
Barium	NE	69.1(5)	3.8(5)	25.7	5/5	22.1-26.4	5	2	Yes	
Calcium	NE	NE	NE	17,567	5/5	1,740-1,960	NA	0	No	Below Background
Iron	1,000	NE	1,000(2)	576	5/5	292-834	0	2	Yes	Terrestrial Concern
Lead	25	13.98(3)	0.54(3)	ND	4/5	1-2.2	4	4	Yes	
Magnesium	NE	NE	NE	1,745	5/5	678-809	NA	0	No	Below Background
Manganese	NE	1,470(5)	80.3(5)	ND	5/5	4.7-10	0	5	Yes	Terrestrial Concern

TABLE 7-2 (Continued)

FREQUENCY AND RANGE OF CONTAMINANT DETECTIONS
COMPARED TO SURFACE WATER SCREENING VALUES
SITE 63 - VERONA DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Water Screening Values (SWSV)			Average Reference Station Concentration	Contaminant Frequency/Range		No. of Positive Detects Above Lowest SWSV	No. of Positive Detects Above the Average Reference Station Concentration	Ecological COPC?	Comments
	North Carolina Water Quality Standards (WQS)[1]	USEPA Region IV Water Quality Screening Values (WQSV)			No. of Positive Detects/ No. of Samples	Range of Positive Detections				
		Acute	Chronic							
Inorganics (µg/L) (continued)										
Sodium	NE	NE	NE	9830	5/5	4,250-4,480	NA	0	No	Below Background
Zinc	50	36.15[3]	32.75[3]	ND	5/5	5.5-22.6	0	5	Yes	Terrestrial Concern

Notes:

ND = Not Detected
NE = Not Established
NA = Not Applicable

(1) NC DEHNR, 1996 (Water Quality Standards).
(2) USEPA, 1995b (Region IV Toxic Substance Spreadsheet).
(3) Criteria are hardness dependent; values are based on a hardness of 25 mg/L as $CaCO_3$.
(4) USEPA, 1995b (Region III BTAG Screening Levels).
(5) Suter and Mabrey, 1994 (Toxicological Benchmarks for Screening Potential COCs for Effects on Aquatic Biota).

TABLE 7-3

FREQUENCY AND RANGE OF CONTAMINANT DETECTIONS
COMPARED TO SEDIMENT SCREENING VALUES
SITE 63 - VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Sediment Screening Values (SSV)			Average Reference Station Concentration	Contaminant Frequency/Range		No. of Positive Detects Above Lowest SSV	No. of Positive Detect Above the Average Reference Concentration	Ecological COPC?	Comments
	ER-L[1]	ER-M[1]	SQC[3]		No. of Positive Detects/ No. of Samples	Range of Positive Detections				
Pesticides (µg/kg)										
alpha-Chlordane	0.5[2][6]	6[2][6]	11.5[6]	1.2	1/5	4.7J	1	1	Yes	
gamma-Chlordane	0.5[2][6]	6[2][6]	11.5[6]	1.44	1/5	6.2J	1	1	Yes	
4,4'-DDD	2[2]	20[2]	14.7	1.57	2/5	2.6J-11J	2	2	Yes	
4,4'-DDE	2.2	27	84	2.42	1/5	4.2J	1	1	Yes	
4,4'-DDT	1.58	46.1	4.6	2.2	1/5	1.6J	1	0	No	Below Background
Inorganics (mg/kg)										
Aluminum	NE	NE	NE	1,166	5/5	890-7,050	NA	4	Yes	
Arsenic	8.2	70	NE	0.37	2/5	0.29J-0.63J	0	1	No	Below SSV
Barium	NE	500[4]	NE	6.46	5/5	3.8-19.6	0	4	No	Below SSV
Beryllium	NE	0.36[5]	NE	0.09	1/5	0.14J	0	1	No	Below SSV
Calcium	NE	NE	NE	1,967	5/5	49.9-178	NA	0	No	Below Background/ Low Toxicity
Chromium	81	370	NE	1.86	4/5	1.4J-8.1J	0	2	No	Below SSV
Copper	34	270	NE	0.75	4/5	2.8-6.9	.0	4	No	Below SSV
Iron	NE	27,000[5]	NE	434	5/5	84.9J-2,050J	0	2	No	Below SSV
Lead	46.7	218	NE	0.79	5/5	3.2J-13.7	0	5	No	Below SSV

TABLE 7-3 (Continued)

FREQUENCY AND RANGE OF CONTAMINANT DETECTIONS
COMPARED TO SEDIMENT SCREENING VALUES
SITE 63 - VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Sediment Screening Values (SSV)			Average Reference Station Concentration	Contaminant Frequency/Range		No. of Positive Detects Above Lowest SSV	No. of Positive Detect Above the Average Reference Concentration	Ecological COPC?	Comments
	ER-L[1]	ER-M[1]	SQC[3]		No. of Positive Detects/ No. of Samples	Range of Positive Detections				
Inorganics (mg/kg) (continued)										
Magnesium	NE	NE	NE	45.25	5/5	11.3J-259	NA	2	No	Low Toxicity
Manganese	NE	230[5]	NE	3.63	5/5	1.6J-7.5J	0	2	No	Below SSV
Nickel	20.9	51.6	NE	ND	1/5	1.9	0	1	No	Below SSV
Potassium	NE	NE	NE	ND	4/5	27.4-367	NA	4	No	Low Toxicity
Sodium	NE	NE	NE	ND	5/5	7.6-12.9	NA	5	No	Low Toxicity
Vanadium	NE	NE	NE	1.52	5/5	1.2J-12.4J	NA	2	Yes	
Zinc	150	410	NE	5.11	5/5	0.92-6.7	0	2	No	Below SSV

Notes:

ND =Not Detected
NE = Not Established
ER-L = Effects Range Low
SQC - Sediment Quality Criteria
NA = Not Applicable
ER-M = Effects Range Median
(1) Long et.al., 1995. Unless otherwise noted.
(2) Long and Morgan, 1991.
(3) Values were calculated using the following equation:

SQC = Foc*Koc*FCV/1000000

Where:

Foc = Fraction of organic carbon in the sediments (used 19,080 mg/kg)
Koc = Organic carbon partition coefficient (chemical specific)
FCV = Final water chronic value (chemical specific)

(4) Sulliven et al., 1985.
(5) Tetra Tech Inc., 1986 (Apparent Effects Threshold Sediment Quality Values).
(6) Value for total chlordane

TABLE 7-4

CONTAMINANTS OF POTENTIAL CONCERN PER MEDIA
SITE 63 - VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Water		Sediment	Surface Soil
	Aquatic Receptors	Terrestrial Receptors		
Pesticides/PCBs				
alpha-Chlordane			X	
gamma-Chlordane			X	
4,4'-DDD			X	
4,4'-DDE			X	X
4,4'-DDT				X
Dieldrin				X
Endosulfan Sulfate				X
Inorganics				
Aluminum	X	X	X	X
Arsenic				X
Barium	X	X		X
Beryllium				X
Chromium				X
Cobalt				X
Copper				X
Iron		X		X
Lead	X	X		X
Manganese		X		X
Mercury				X
Nickel				X
Vanadium			X	
Zinc		X		X

TABLE 7-5

PHYSICAL/CHEMICAL CHARACTERISTICS OF THE CONTAMINANTS OF POTENTIAL CONCERN
SITE 63 - VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Potential Concern	BCF	Organic Carbon Partition Coefficient (mL/g)	Log Octanol/ Water Coefficient	Biotransfer Factors		
				Bv[1][2]	Br[1][2]	Bb[1][2]
Pesticides/PCBs						
alpha-Chlordane	14,100[3]	140,000[5]	5.5[6]	2.56e-02	2.56e-02	7.94e-03
gamma-Chlordane	14,100[3]	140,000[5]	5.5[6]	2.56e-02	2.56e-02	7.94e-03
4,4'-DDD	53,600[3]	770,000[5]	6[6]	1.32e-02	1.32e-02	2.51e-02
4,4'-DDE	53,600[3]	4,400,000[5]	5.7[6]	2.00e-02	2.00e-02	1.26e-02
4,4'-DDT	53,600[3]	243,000[5]	6.4[6]	8.00e-03	8.00e-03	6.31e-02
Dieldrin	4,670[3]	177,828[7]	5.34[7]	3.17e-02	3.17e-02	5.50e-03
Endosulfan Sulfate	270[3]	3,162[8]	3.1[6]	6.25e-01	6.25e-01	3.16e-05
Inorganics						
Aluminum	231[4]	ND	ND	4.00e-03	6.50e-04	1.50e-03
Arsenic	44[3]	ND	ND	4.00e-02	6.00e-03	2.00e-03
Barium	8[4]	ND	ND	1.50e-01	1.50e-02	1.50e-04
Beryllium	19[3]	ND	ND	1.00e-02	1.50e-03	1.00e-03
Chromium	16[3]	ND	ND	7.50e-03	4.50e-03	5.50e-03
Cobalt	40[4]	ND	ND	2.00e-02	7.00e-03	2.00e-02
Copper	36[3]	ND	ND	4.00e-01	2.50e-01	1.00e-02
Iron	ND	ND	ND	4.00e-03	1.00e-03	2.00e-02
Lead	49[3]	ND	ND	4.50e-02	9.00e-03	3.00e-04
Manganese	35[4]	ND	ND	2.50e-01	5.00e-02	4.00e-04
Mercury	5,500[3]	ND	ND	9.00e-01	2.00e-01	2.50e-01
Nickel	47[3]	ND	ND	6.00e-02	6.00e-02	6.00e-03
Vanadium	ND	ND	ND	5.50e-03	3.00e-03	2.50e-03
Zinc	47[3]	ND	ND	1.50e+00	9.00e-01	1.00e-01

Notes:

[1] Baes et al., 1984 for the inorganics.
[2] The organics were calculated using Travis and Arms, 1988.
[3] USEPA, 1995b (Region IV).
[4] USEPA, 1995a (Region III).
[5] USEPA, 1986.
[6] SCDM, 1991.
[7] USEPA, 1993c (sediment Quality Criteria for Dieldrin).
[8] ASTDR, 1993 (Toxicological Profile for Endosulfan).

BCF = Bioconcentration Factor
ND = No Data
Bv = Biotransfer factor for vegetation (stems, leaves)
Br = Biotransfer factor for vegetation (berries, fruits)
Bb = Biotransfer factor for beef

TABLE 7-6

SEDIMENT CHARACTERIZATION SUMMARY
SITE 63 - VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Station	Percent Gravel	Percent Sand	Percent Silt/Clay	Sediment Description
63-SD01	0	95	5	reddish brown with organic debris
63-SD02	0	91	9	reddish brown with organic debris
63-SD03	0	81	19	brown
63-SD04	2	59	39	light brown
63-SD05	3	91	6	gray-brown

Notes:

SD = Sediment Sample

TABLE 7-7

FIELD CHEMISTRY DATA
SITE 63 - VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Station	Temperature (°C)	pH (S.U.)	Dissolved Oxygen (mg/L)	Conductivity (μmhos/cm)
63-SW/SD01	14.8	3.99	4.7	73.6
63-SW/SD02	13.4	3.90	4.7	73.0
63-SW/SD03	13.0	3.84	4.3	72.0
63-SW/SD04	12.2	3.91	7.2	68.9
63-SW/SD05	12.9	3.62	7.5	84.1

Notes:

°C = Degrees Centigrade
mg/L = Miligrams per Liter
S.U. = Standard Units
μmhos/cm = Micromhos per centimeter

TABLE 7-8

FREQUENCY AND RANGE OF CONTAMINANTS OF POTENTIAL CONCERN
COMPARED TO SOIL FLORA AND FAUNA SCREENING VALUES
SITE 63 - VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Soil Flora and Fauna Screening Values(1)				Contaminant Frequency/Range		No. of Positive Detects Above Lowest Screening Value
	Plant	Earthworm	Invertebrate	Microorganisms and Microbial Processes	No. of Positive Detects/No. of Samples	Range of Positive Detections	
Pesticides/PCBs (µg/kg)							
4,4'-DDE	NE	100(2)	100(2)	NE	7/45	2.7J-55J	0
4,4'-DDT	NE	4(2)	4(2)	NE	11/45	2J-50J	5
Dieldrin	NE	100(2)	100(2)	NE	3/46	3J-4.1J	0
Endosulfan Sulfate	1,000(3)	NE	NE	NE	4/45	1.9J-2.8J	0
Inorganics (mg/kg)							
Aluminum	50	NE	NE	600	46/46	268J-7,050J	46
Arsenic	10	60	NE	100	36/46	0.32-3.7	0
Barium	500	400(2)	400(2)	3,000	46/46	3-53.1	0
Beryllium	10	NE	NE	NE	5/46	0.1J-0.27	0
Chromium	1	0.4	0.0075(2)	10	44/46	1.1-11.1	44
Cobalt	20	1,500(2)	1,.500(2)	1000	7/46	0.49-4.3	0
Copper	100	50	20	100	29/46	0.47-74.8	3
Iron	100(2)	NE	3,515	200	46/46	590-22,400J	46
Lead	50	500	300	900	46/46	2.6-107	3
Manganese	500	330(2)	330(2)	100	46/46	3.4J-348J	2
Mercury	0.3	0.1	300	30	4/46	0.06-0.21J	1

TABLE 7-8 (Continued)

FREQUENCY AND RANGE OF CONTAMINANTS OF POTENTIAL CONCERN
COMPARED TO SOIL FLORA AND FAUNA SCREENING VALUES
SITE 63 - VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Soil Flora and Fauna Screening Values[1]				Contaminant Frequency/Range		No. of Positive Detects Above Lowest Screening Value
	Plant	Earthworm	Invertebrate	Microorganisms and Microbial Processes	No. of Positive Detects/No. of Samples	Range of Positive Detections	
Inorganics (mg/kg) (Continued)							
Nickel	30	200	NE	90	33/46	0.62J-9.8	0
Zinc	50	200	500	100	36/46	0.98-1,860	4

Notes:

[1] Will and Suter, 1994a and 1994b unless indicated otherwise. (Values presented for plants, earthworms, and microorganisms and microbial processes are benchmarks below which adverse inpacts to these species are not expected. Values for invertebrates are No Observed Effects Concentrations however, they are based on less data than the benchmarks).
[2] USEPA, 1995b (Region III BTAG Soil Screening Values for Soil Fauna).
[3] Hulzebos et al., 1993 (EC_{50}).

NE = Not Established
NA = Not Applicable

TABLE 7-9

EXPOSURE FACTORS FOR TERRESTRIAL CHRONIC DAILY INTAKE MODEL
SITE 63 - VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Exposure Parameter	Units	White-Tailed Deer	Eastern Cottontail Rabbit	Bobwhite Quail	Red Fox	Raccoon	Small Mammal
Food Source Ingestion	NA	Vegetation 100%	Vegetation 100%	Vegetation 100%	Small Mammals 80% Vegetation 20%	Vegetation 40% Fish 60%	Vegetation 100%
Feeding Rate	kg/day	1.6[1]	0.237[3]	0.0135[5]	0.601[5]	0.214[6]	0.112[5]
Incident Soil Ingestion	kg/day	0.0185[2]	0.0057[4]	0.0011[4]	0.0168[4]	0.0201[4]	0.00269[4]
Rate of Drinking Water Ingestion	L/day	1.1[1]	0.119[5]	0.0191[5]	0.385[5]	0.422[5]	0.0652[5]
Rate of Vegetation Ingestion	kg/day	1.6	0.237	0.0135	0.12	0.086	0.112
Body Weight	kg	45.4[1]	1.189[5]	0.174[5]	4.54[5]	5.12[5]	0.3725[5]
Rate of Small Mammal Ingestion	kg/day	NA	NA	NA	0.48	NA	NA
Rate of Fish Ingestion	kg/day	NA	NA	NA	NA	0.128	NA
Home Range Size	acres	454[1]	9.30[5]	26.24[5]	1,245[5]	257[5]	0.032[5]

Notes:

NA = Not Applicable

[1] Dee, 1991.
[2] Arthur and Alldridge, 1979.
[3] Opresko, et al., 1994.
[4] Beyer, et al., 1993.
[5] USEPA, 1993d.
[6] Nagy, 1987.

TABLE 7-10

SURFACE WATER QUOTIENT INDEX PER STATION
SITE 63 - VERONA LOOP DUMP
REMEDIAL INVESTIGATION CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Station	Concentration (µg/L)	Quotient Index		
			North Carolina WQS	USEPA SWSV	
				Acute	Chronic
Total Inorganics					
Aluminum	63-SW01	627	NA	0.84	7.21
	63-SW02	650.0	NA	0.87	7.47
	63-SW03	653.0	NA	0.87	7.51
	63-SW04	602.0	NA	0.80	6.92
	63-SW05	688.0	NA	0.92	7.91
Barium	63-SW01	22.1	NA	0.32	5.82
	63-SW02	24.6	NA	0.36	6.47
	63-SW03	26.4	NA	0.38	6.95
	63-SW04	26.0	NA	0.38	6.84
	63-SW05	23.7	NA	0.34	6.24
Lead	63-SW02	1.0	0.04	0.07	1.85
	63-SW03	2.2	0.09	0.16	4.07
	63-SW04	1.2	0.05	0.09	2.22
	63SW05	1.6	0.06	0.11	2.96

Notes:

Shaded samples are Quotient Indices that exceed 1.
NA = Not Available
WQS = Water Quality Standard
SWSV = Surface Water Screening Value

TABLE 7-11

SURFACE WATER QUOTIENT INDEX PER CONTAMINANT OF POTENTIAL CONCERN
SITE 63 - VERONA LOOP DUMP
REMEDIAL INVESTIGATION CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Average Concentration (μg/L)	Quotient Index Ratio		
		North Carolina WQS	USEPA SWSV	
			Acute	Chronic
Total Inorganics				
Aluminum	644	NA	0.86	7.40
Barium	24.6	NA	0.36	6.47
Lead	1.3	0.05	0.09	2.41
TOTAL QI		0.05	1.31	16.28

Notes:

Shaded samples are Quotient Indices that exceed 1.
NA = Not Available
WQS = Water Quality Standard
SWSV = Surface Water Screening Value
QI = Quotient Index

TABLE 7-12

SEDIMENT QUOTIENT INDEX PER STATION
SITE 63 - VERONA LOOP DUMP
REMEDIAL INVESTIGATION CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Station	Concentration	Quotient Index		
			ER-L	ER-M	SQC
Pesticides (µg/kg)					
alpha-Chlordane	63SD04-01	4.7J	9.40	0.78	0.65
gamma-Chlordane	63SD04-01	6.2J	12.40	1.03	0.86
4,4'-DDD	63SD03-01	2.6J	1.30	0.13	0.34
	63SD04-01	11J	5.50	0.55	1.19
4,4'-DDE	63SD04-01	4.2J	1.91	0.16	0.08

Notes:

Shaded samples are Quotient Indices that exceed 1.
ER-L = Effects Range Low
ER-M = Effects Range Median
SQC = Sediment Quality Criteria

TABLE 7-13

SEDIMENT QUOTIENT INDEX PER CONTAMINANT OF POTENTIAL CONCERN
SITE 63 - VERONA LOOP DUMP
REMEDIAL INVESTIGATION CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Average Concentration	Quotient Index		
		ER-L	ER-M	SQC
Pesticides (µg/kg)				
alpha-Chlordane	1.86	3.72	0.31	0.16
gamma-Chlordane	2.16	4.32	0.36	0.19
4,4'-DDD	4.13	2.07	0.21	0.28
4,4'-DDE	2.68	1.22	0.10	0.03
TOTAL QI		11.33	0.98	0.66

Notes:

Shaded samples are Quotient Indices that exceed 1.
ER-L = Effects Range Low
ER-M = Effects Range Median
SQC = Sediment Quality Criteria
QI = Quotient Index

TABLE 7-14

TERRESTRIAL QUOTIENT INDEX
SITE 63 - VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Red Fox	Bobwhite Quail	Cottontail Rabbit	Raccoon	Whitetail Deer
4,4'-DDE	1.94e-07	6.64e-05	3.41e-05	9.48e-07	2.97e-07
4,4'-DDT	1.88e-07	6.04e-05	2.56e-05	9.67e-07	1.90e-07
Dieldrin	5.94e-06	6.61e-05	3.79e-03	8.97e-05	5.45e-08
Endosulfan Sulfate	2.20e-07	1.59e-06	3.49e-04	2.28e-06	4.17e-06
Aluminum	5.72e-03	3.21e-01	9.16e-01	1.22e+01	5.79e-03
Arsenic	7.77e-04	1.89e-04	2.27e-03	3.31e-03	5.91e-05
Barium	2.50e-02	3.48e-02	2.20e-01	8.39e-02	1.15e-02
Beryllium	4.16e-06	1.20e-04	6.09e-04	2.09e-05	4.71e-06
Chromium	7.44e-05	9.06e-05	2.83e-04	3.84e-04	5.53e-06
Cobalt	1.96e-05	9.14e-04	3.50e-03	9.40e-05	8.10e-05
Copper	1.42e-04	6.41e-03	7.49e-02	4.04e-04	4.70e-03
Iron	6.74e-03	6.63e-02	3.78e-01	1.93e-02	6.47e-03
Lead	1.47e-04	8.66e-03	6.80e-02	1.27e-03	2.07e-03
Manganese	5.95e-04	1.16e-03	4.22e-02	3.53e-03	2.79e-03
Mercury	3.09e-05	3.07e-03	2.48e-02	3.25e-05	8.16e-04
Nickel	1.34e-06	2.02e-04	6.37e-03	9.63e-05	1.75e-04
Zinc	6.87e-03	1.49e-02	2.54e-01	2.98e-04	8.15e-03
Total Quotient Index	**4.61e-02**	**4.58e-01**	**2.00e+00**	**1.23e+01**	**4.26e-02**

Note:

Shaded areas are Quotient Indices that exceed 1.

TABLE 7-14

TERRESTRIAL QUOTIENT INDEX
SITE 63 - VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Red Fox	Bobwhite Quail	Cottontail Rabbit	Raccoon	Whitetail Deer
4,4'-DDE	1.94e-07	6.64e-05	3.41e-05	9.48e-07	2.97e-07
4,4'-DDT	1.88e-07	6.04e-05	2.56e-05	9.67e-07	1.90e-07
Dieldrin	5.94e-06	6.61e-05	3.79e-03	8.97e-05	5.45e-08
Endosulfan Sulfate	2.20e-07	1.59e-06	3.49e-04	2.28e-06	4.17e-06
Aluminum	5.72e-03	3.21e-01	9.16e-01	1.22e+01	5.79e-03
Arsenic	7.77e-04	1.89e-04	2.27e-03	3.31e-03	5.91e-05
Barium	2.50e-02	3.48e-02	2.20e-01	8.39e-02	1.15e-02
Beryllium	4.16e-06	1.20e-04	6.09e-04	2.09e-05	4.71e-06
Chromium	7.44e-05	9.06e-05	2.83e-04	3.84e-04	5.53e-06
Cobalt	1.96e-05	9.14e-04	3.50e-03	9.40e-05	8.10e-05
Copper	1.42e-04	6.41e-03	7.49e-02	4.04e-04	4.70e-03
Iron	6.74e-03	6.63e-02	3.78e-01	1.93e-02	6.47e-03
Lead	1.47e-04	8.66e-03	6.80e-02	1.27e-03	2.07e-03
Manganese	5.95e-04	1.16e-03	4.22e-02	3.53e-03	2.79e-03
Mercury	3.09e-05	3.07e-03	2.48e-02	3.25e-05	8.16e-04
Nickel	1.34e-06	2.02e-04	6.37e-03	9.63e-05	1.75e-04
Zinc	6.87e-03	1.49e-02	2.54e-01	2.98e-04	8.15e-03
Total Quotient Index	**4.61e-02**	**4.58e-01**	**2.00e+00**	**1.23e+01**	**4.26e-02**

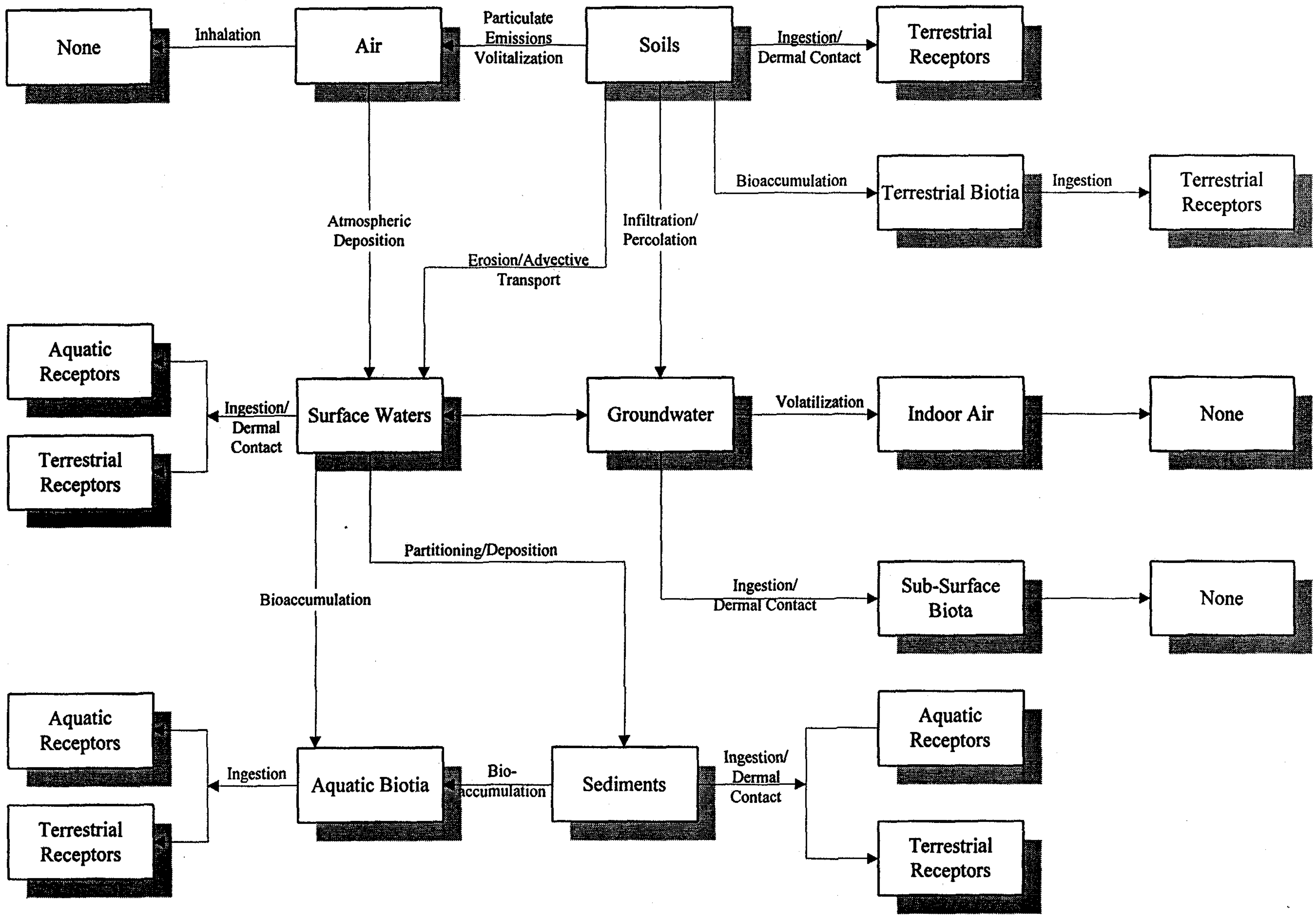
Note:

Shaded areas are Quotient Indices that exceed 1.

SECTION 7.0 FIGURES

FIGURE 7-1

CONCEPTUAL EXPOSURE MODEL FOR ECOLOGICAL RECEPTORS
SITE 63 - VERONA LOOP DUMP
REMEDIAL INVESTIGATION, CTO-0340
MCB, CAMP LEJEUNE, NORTH CAROLINA



8.0 CONCLUSIONS AND RECOMMENDATION

This RI report has evaluated the nature and extent of potential threats to public health and the environment posed by the release or threatened release of hazardous substances, pollutants, or contaminants at OU No. 13 (Site 63), MCB, Camp Lejeune, North Carolina. Furthermore, the report has supplied information and findings that support the Feasibility Study, Proposed Remedial Action Plan, and Record of Decision documents. The field investigation included sampling of soil, groundwater, surface water, and sediment environmental media; the resultant analytical data were evaluated; and both human health and ecological risk assessments were performed. The subsections which follow describe the conclusions and recommendation of this RI.

8.1 Conclusions

Based upon the information and findings supplied within this RI report, the following conclusions are presented.

8.1.1 Carcinogenic Risks

There are no unacceptable site-related carcinogenic risks associated with exposure to environmental media at Site 63. Multiple exposure pathways were evaluated for current and future potential human receptors; resultant estimates indicate that carcinogenic site risks are within the acceptable risk range as defined by USEPA.

8.1.2 Noncarcinogenic Risks

An assessment of potential noncarcinogenic risks posed by exposure to environmental media at Site 63 was also completed for possible current and future human receptors. This conservative evaluation of site risk suggests that future residents, given a number of exposure assumptions, could experience some adverse health effects. The evaluation was based upon the potential exposure of future child and future adult residents. Over 90 percent of noncarcinogenic risk generated by the future residential scenario is the result of presumed shallow groundwater ingestion. Ingestion of iron and zinc at the maximum concentrations detected among all groundwater samples obtained from Site 63 were used in the estimation of risk. Additionally, ingestion of iron and lead at the maximum concentrations detected among soil samples constituted the remaining noncarcinogenic risk to future child residents. It is important to note that this risk assessment is highly protective of human health and that future residential development of the site is unlikely.

8.1.3 Surficial Aquifer as Drinking Water Source

The majority of site-related noncarcinogenic risk to future residents was generated by possible ingestion of inorganic analytes in groundwater (refer to Conclusion No. 2). Hydraulic conductivity results from Site 63 suggest that potable wells supplying groundwater for human consumption from the uppermost portion of the surficial aquifer would not be practical. Groundwater flow rates would not be sufficient to support a potable source of drinking water. In addition, suspended material resulting from loose surficial soils would further inhibit groundwater flow capacities through siltation. Given these circumstances, it is unlikely that the surficial aquifer could be used as a drinking water source. If a potable well were required in the future at Site 63 it would most likely supply groundwater from the deeper, Castle Hayne aquifer.

8.1.4 Ecological Risks

An ecological risk assessment of potential site-related impacts to both aquatic and terrestrial ecosystems was performed. Based upon this assessment, the significance of potential risks to ecological receptors at Site 63 is considered negligible. Environmental media were assessed to determine the theoretical risks posed to various on-site ecological communities. Results of the ecological risk assessment indicate that the aquatic environment may potentially be impacted by pesticides detected in the sediment and that risks posed to the terrestrial environment are a result of naturally occurring inorganic analytes detected in surface water and surface soil. Similar aquatic and terrestrial risks have been demonstrated by reference samples collected throughout MCB, Camp Lejeune from areas not known or suspected of having been impacted by facility operations.

8.1.5 Positive Detections in Excess of Screening Criteria

A number of organic compounds and inorganic analytes were detected among environmental samples obtained from Site 63 at concentrations which exceeded screening criteria promulgated by either state or federal agencies (refer to Section 4.0). Dieldrin, n-nitrosodiphenylamine, arsenic, barium, and nickel were detected at concentrations exceeding USEPA Region III Soil Screening Levels Protective of Groundwater among at least 7 of the 96 soil samples. Iron, manganese, and zinc were the only TAL metals detected in groundwater at concentrations in excess of state or federal screening standards. Iron and manganese detections exceeded applicable state standards among 4 of the 11 shallow groundwater samples, but fell within the range of concentrations for samples collected elsewhere at MCB, Camp Lejeune. Only one positive detection of zinc exceeded the state groundwater standard. Aluminum was the only TAL total metal identified among each of the five surface water samples obtained from the unnamed tributary that exceeded state or federal chronic screening values. The pesticides 4,4'-DDE, 4,4'-DDD, 4,4'-DDT, alpha-chlordane, and gamma-chlordane were detected in one of the five sediment samples retained for analysis from Site 63. The only other pesticide detection was that of 4,4'-DDD in a sample obtained from an upstream station. Each of the six pesticide detections exceeded applicable NOAA ER-L chronic sediment screening values.

8.1.6 Prevalence of Inorganic Analytes in Site Media

Inorganic analytes were detected in each soil, groundwater, surface water, and sediment sample obtained during the field investigation at Site 63. Analytes such as aluminum, arsenic, iron, lead, manganese, and zinc were principal contributors to both human health and ecological site risks. These and other inorganic analytes naturally occur, often abundantly, in site media. No discernible pattern of analyte distribution was evident among the various media sampled. Former site operations do not appear to have contributed to the presence or frequency of these analytes.

8.2 <u>Recommendation</u>

Based upon the conclusions provided in Section 8.1, the following recommendation is presented.

8.2.1 No Further Action

A Proposed Remedial Action Plan that details a "No Further Action Alternative" should be prepared for Site 63. Project tasks associated with the screening and evaluation of remedial technologies and the subsequent preparation of a Feasibility Study report, given acceptance of the recommended alternative, will not be required. In addition, the three permanent monitoring wells that were installed at Site 63 during the 1991 Site Inspection should be abandoned (i.e., removed). Prior to project completion and following approval of the Record of Decision, abandonment of monitoring wells 63-GW01, 63-GW02, and 63-GW03 should proceed according to procedures stipulated by North Carolina DEHNR.